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Environmental Impact Statement

EnergyConnect (NSW – Eastern Section)

Technical paper 8 – Hydrology, flooding and water quality

Transgrid

EnergyConnect
(NSW – Eastern Section)

Technical Paper 8 –
Hydrology and Flooding Impact Assessment

DECEMBER 2021

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Glossary

AEP	Annual Exceedance Probability. The probability that a design event (rainfall or flood) has of occurring in any 1 year period.
Afflux	With reference to flooding, afflux refers to the predicted change, usually in flood levels, between two scenarios. It is frequently used as a measure of the change in flood levels, between an existing scenario and a proposal scenario.
AHD	Australian height datum
ANZECC	Australian and New Zealand Environment Conservation Council
ARR	Australian Rainfall and Runoff
AIDR	Australian Institute for Disaster Resilience
Barrage	A type of diversion dam that can be used to regulate river flows
The Blue Book	The *Managing Urban Stormwater – Soils and Construction* (Landcom, 2004) series of handbooks, also known as the Blue Book, are an element of the NSW Government's urban stormwater program specifically applicable to the construction phase of developments. These provide guidance for managing soils in a manner that protects the health, ecology and amenity of urban streams, rivers estuaries and beaches through better management of stormwater quality.
BoM	Bureau of Meteorology
Catchment	The area drainage by a stream or body of water or the area of land from which water is collected.
construction impact area	Refers to the area that would be directly impacted by construction of the proposal comprising the following: — construction of all proposal infrastructure elements (including the proposed transmission line alignment, transmission line easement, substation site works (at both the proposed Dinawan 330kV and upgraded and expanded Wagga Wagga substations), optical repeater infrastructure, and other ancillary works) — locations for construction elements such as construction compounds and accommodation camps, access tracks (excluding public roads proposed to be used for access routes), site access points, water supply points, laydown and staging areas, concrete batching plants, brake/winch sites and site offices. The area is identified based on realistic project component locations and areas however it is indicative at this stage. The area would be confirmed during finalisation of the design and construction methodology and would be developed as part of the consideration of avoidance and impact minimisation. This area includes the operational impact area (including areas required for maintenance) (refer definition below).
DEM	Digital Elevation Model
DO	Dissolved oxygen
EC	Electrical conductivity

EY	Exceedances per year. Used to define the frequency of occurrence of more frequent rainfall or flood events. For example, a design event (rainfall or flood) that has a chance of occurring once during every 6 month period is expressed as having 2 Exceedances per Year (2EY).
Earthworks	All operations involved in loosening, excavating, placing, shaping and compacting soil or rock.
EnergyConnect	An electrical interconnector of around 900 kilometres between the electricity grids of South Australia and New South Wales, with an added connection to north west Victoria. In NSW, EnergyConnect comprises two sections – Western Section (which has been the subject of a separate environmental assessment and approval) and the Eastern Section (the proposal the subject of this EIS).
Erosion	A natural process where wind or water detaches a soil particle and provides energy to move the particle.
Flood prone land	Land susceptible to flooding by the probable maximum flood. Note that the flood prone land is also known as flood liable land.
Flood storage area	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. It is necessary to investigate a range of flood sizes before defining flood storage areas.
Floodplain	Area of land which is inundated by floods up to and including the probable maximum flood event (i.e. flood prone land).
Freeboard	A factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted flood planning level and the peak height of the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as 'greenhouse' and climate change. Freeboard is included in the Flood Planning Level.
GDE	Groundwater dependent ecosystems (GDEs) are defined as ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services'.
GIS	Geographic information systems
Groundwater	Water found in the saturated zone below the water table or piezometric surface
Hydrology	Term given to the study of the rainfall and runoff process, including surface and groundwater interaction; with particular focus on the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
Hydrology and flooding study area	The study area for this EIS, which comprises a one kilometre wide corridor between Buronga substation and the Wagga Wagga substation. Encompasses the disturbance area and a buffer zone which has been applied to identify the constraints nearby to the proposal which may or may not be indirectly impacted by the proposal.
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment.

Infiltration	The downward movement of water into soil and rock. It is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil. The downward movement of water into soil and rock. It is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil.
km	kilometres
LEP	Local Environmental Plan
LGA	Local government area
LiDAR	Light Detecting and Ranging
NSW	New South Wales
OEH	Office of Environment and Heritage (NSW Government)
Operational impact footprint	Refers to the area that would be directly impacted by permanent components of the proposal, including all proposed infrastructure elements such as the proposed transmission line easement, transmission line and transmission towers, any new or upgraded substation infrastructure and permanent access tracks.
OSD	On site detention
PMF	Probable maximum flood. The flood that occurs as a result of the probable maximum precipitation on a study catchment. The probable maximum flood is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The probable maximum flood defines the extent of flood prone land (i.e. the floodplain).
PMP	Probable Maximum Precipitation
ppm	parts per million
Peak discharge	The maximum discharge occurring during a flood event.
Peak flood level	The maximum water level occurring during a flood event.
Pollutant	Any measured concentration of solid or liquid matter that is not naturally present in the environment.
(the) proponent	NSW Electricity Networks Operations Pty Ltd as a trustee for NSW Electricity Operations Trust (referred to as Transgrid). Transgrid is the operator and manager of the main high voltage (HV) transmission network in NSW and the Australian Capital Territory (ACT), and is the Authorised Network Operator (ANO) for the purpose of an electricity transmission or distribution network under the provisions of the Electricity Network Assets (Authorised Transactions) Act 2015.

(the) proposal	The proposal is known as 'EnergyConnect (NSW – Eastern Section)' The proposal would involve the following key features: — about 375 kilometres of new 330 kilovolt (kV) double circuit transmission line and associated infrastructure between the Buronga substation and the proposed Dinawan 330kV substation — connection of the proposed transmission lines to the existing Buronga 330kV substation — construction of a new 330kV substation around 30 kilometres south of Coleambally, referred to as the proposed Dinawan 330kV substation — about 162 kilometres of new 500kV double circuit transmission line and associated infrastructure between the proposed Dinawan 330kV substation and the existing Wagga Wagga substation at Wagga Wagga, NSW — upgrade and expansion of the Wagga Wagga substation to accommodate three new line bays, two reallocated bays and associated civil works (road, kerb, gutter, drainage works and earthworks) — provision of three optical repeater structures and associated connections to existing local electrical supplies — new and/or upgrade of access tracks as required — ancillary works required to facilitate the construction of the proposal (e.g. laydown and staging areas, concrete batching plants, brake/winch sites, site offices and accommodation camps).
Runoff	The amount of rainfall that ends up as streamflow, also known as rainfall excess.
SES	State Emergency Services
Simple hazard	Referring to flood hazard, the simple hazard is the product of the maximum depth of floodwaters and the maximum velocity of floodwaters.
Stream order	A classification system which assigns an 'order' to waterways according to the number of additional tributaries associated with each waterway, to provide a measure of system complexity.
TDS	Total dissolved solids
TN	Total Nitrogen
TP	Total Phosphorous
Transmission line easement	An area surrounding and including the transmission lines, which is a legal right and allows for ongoing access and maintenance of the lines and will be acquired from landholders either by agreement or pursuant to compulsory acquisition process. The easement width would be 80 metres wide.
TSS	Total Suspended Solids
VIC	Victoria
WM Act	Water Management Act 2000 (NSW)
Waterway	Any flowing stream of water, whether natural or artificially regulated (not necessarily permanent).

Executive summary

EnergyConnect (NSW – Eastern Section)

Transgrid (electricity transmission operator in New South Wales (NSW)) and ElectraNet (electricity distributor in South Australia (SA)) are currently investigating the proposed construction and operation of a new electrical interconnector and network support options between NSW and SA, with an added connection to north-west Victoria.

The proposal, focusing on the eastern section of EnergyConnect in NSW, would include the construction and operation of new high voltage transmission lines between the existing Buronga substation and existing Wagga Wagga substation, a new 330kV substation (referred to as the proposed Dinawan 330kV substation), upgrade and expansion of the existing Wagga Wagga substation as well as other ancillary infrastructure.

Overview

This technical paper has been prepared to support the environmental impact statement (EIS) for the proposal and assess the impacts to flooding and hydrology during construction and operation of the proposal. It considers impacts to:

- flooding
- geomorphology
- water quantity
- water quality.

This assessment has considered the wider catchment area of the Lower Murray Darling, Mid-Murray and Murrumbidgee catchments. These elements are subject to conditions of the Basin Plan 2012 (Murray Darling Basin Authority, 2012) which provides a coordinated approach to water use across the Murray–Darling Basin, and provides a framework to balance environmental, social and economic considerations for water use and water quality to an environmentally sustainable level.

Hydrology and flooding impacts

Construction

For the construction phase, the proposal would have negligible impact on flood behaviour because the proposal works in the floodplain are insignificant compared to the extent of the floodplain. Crossing waterways would be avoided when an alternate route is available. If required, access tracks across minor waterways may have localised and temporary impacts on flooding regimes and geomorphic conditions. These impacts would be managed using a minimalist approach to design of waterway crossings, and only if required incorporating temporary culverts and scour protection measures to maintain flows and manage erosion effects around crossings.

Water demands during construction would have a short-term impact on local water supplies and would be managed in consultation with various water providers across the hydrology and flooding study area.

Water quality impacts from construction of the proposal are anticipated to be short-term and limited in extent. The major sensitive elements in the hydrology and flooding study area would be major waterways of 7^{th} level stream order, which are named major rivers, located along the proposal including Box Creek, the Murrumbidgee River, Abercrombie Creek, The Forest Creek, Curtains Creek, Nyangay Creek, Yanco Creek, the Coleambally Outfall Drain and Colombo Creek, medium streams including Hallidays Cut and Burkes Creek and other lower order creeks.

The remainder of the study area is not considered to have any hydrology and flooding sensitive receivers and are therefore is not considered. Further, the progressive nature of construction would limit the work areas and duration within which impacts may occur.

Operation

The proposal would have minimal impact on flood behaviour due to the sparsely located transmission line towers, small physical footprint of the transmission towers and suspended transmission line. Permanent access tracks (where proposed) are not expected to impact flood behaviour, where they are located away from overland flow paths and would also consider the local drainage conditions to result in minimal changes to minor waterways. Permanent watercourse crossings are not proposed at the key watercourses along the proposal. There would be no impact to flood behaviour for the main waterway channels of the major waterways crossed by the proposal. The proposed Dinawan 330kV substation and upgrade and expansion of the existing Wagga Wagga substation are not located within flood prone land and are therefore no impacts to or from flooding are anticipated. The earthworks material site is anticipated to remain unfilled (up to a depth of between one and two metres at the deepest point, subject to final earthwork requirements) of for the purpose of future stock dams (or other use) to be agreed with the property owner. This would create a small amount of additional flood storage to the north of the substation infrastructure. No impacts to the flood affectation of existing structures and roads is expected.

Lakes and waterbodies located along the length of the proposal include Dry Lake, Lake Beanee, Lake Caringay, Waldaira Lake, Condoulpe Lake, Dusty Lake, Five Tree Dam, Lake Urana, Lake Cullivel and Lake Albert, however no impacts are anticipated to these waterbodies.

Additional operational water demands would be confined to the proposed Dinawan 330kV substation and maintenance activities (including the existing Wagga Wagga substation). These demands would be managed through consultation with the relevant local council (such as the Murrumbidgee Council for the proposed Dinawan 330kV substation) to ensure minimal impact to town water supplies and are anticipated to be minimal.

There is potential for operational water quality impacts from runoff from the new impervious area at the proposed Dinawan 330kV substation. The new impervious areas have the potential to cause increased runoff volumes and velocities in receiving catchments, with potential for increased sediment loads. The drainage system at the substation would collect and discharge surface and subsoil water to appropriate containment structures and minimise potential erosion. There are also potential water quality impacts as a result of spills or litter generated from operation and maintenance activities along the transmission lines and at transmission line towers near waterways, however, these impacts would be minor and localised and, provided correct operational procedures and safeguards are implemented, the residual likelihood of impacts would be low. Water quality impacts as a result of the operation of the proposal in all other locations would be negligible.

Mitigation and management

Impacts from the proposal during the construction phase would be managed through a Construction Environmental Management Plan (CEMP) which would include a Soil and Water Management Plan developed in line Landcom's *The Managing Urban Stormwater – Soils and Construction* (2004) guideline.

A key aspect of the mitigation and management of impacts would be the water quality monitoring program. This should begin prior to impact at identified watercourses to provide baseline data and allow for target water quality values to be established for key water quality parameters. These identified watercourses include Murrumbidgee River, Colombo Creek and the irrigation channel near the Dinawan 330kV substation site (between Coleambally Irrigation Area and Yanco Creek). The program should cover the duration of construction activities near the identified watercourses to monitor the soil and water management measures and should the target values be exceeded then mitigation measures would be updated to ensure compliance.

Operational mitigation and management including managing spills, would be developed and implemented as part of the operations environment management plans for the proposal.

Conclusion

The hydrology and flooding assessment has identified the key water resources for the proposal area and determined hydrological and flood affected features, water supply and water quality as susceptible aspects that would need to be managed through the design. A construction environmental management plan with a soil and water management plan would be developed which, provided the identified procedures and safeguards are implemented, would result in minimal impacts to existing water resources. Ongoing water quality management during operation of the proposed Dinawan 330kV substation and maintenance activities would result in minimal impacts to water quality of the water quality environments of the Lower Murray Darling, the Mid-Murray and the Murrumbidgee.

Due to typically low annual rainfall across the hydrology and flooding study area stormwater harvesting is not considered to be feasible and water supply from town water sources would be relied upon. This minimal demand on existing water supplies would be managed through consultation with the water suppliers across the study area to ensure that sufficient capacity within existing water supply systems is available to support the additional demand during the construction and operation phases of the proposal.

1 Introduction

1.1 Proposal context and overview

Transgrid (electricity transmission operator in New South Wales (NSW)) and ElectraNet (electricity transmission operator in South Australia (SA)) are seeking regulatory and environmental planning approval for the construction and operation of a new High Voltage (HV) interconnector between NSW and SA, with an added connection to north west Victoria. Collectively, the proposed interconnector is known as EnergyConnect.

EnergyConnect aims to reduce the cost of providing secure and reliable electricity transmission between NSW and SA in the near term, while facilitating the longer-term transition of the energy sector across the National Electricity Market (NEM) to low emission energy sources.

EnergyConnect has been identified as a priority transmission project in the NSW Transmission Infrastructure Strategy (NSW Department of Planning and Environment (DPE), 2018), linking the SA and NSW energy markets and would assist in transporting energy from the South-West Renewable Energy Zone to major demand centres.

EnergyConnect comprises several sections (shown on Figure 1-1) that would be subject to separate environmental planning approvals under the relevant jurisdictions. It includes:

- NSW sections including:
  - Western section, which would extend from:
    - the SA/NSW border (near Chowilla in SA) to Transgrid's existing Buronga substation
    - Buronga substation to the NSW/Victoria border at Monak (near Red Cliffs in Victoria)
  - Eastern section, which would extend from the Buronga substation to the existing Wagga Wagga 330kV substation
- a Victorian section, which would extend from the NSW/Victoria border to Red Cliffs substation
- a SA section, which would extend from Robertstown to the SA/NSW border.

Transgrid is currently seeking planning approval for the NSW – Eastern Section (the proposal), which is the subject of this EIS.

Transgrid has previously sought and received separate environmental planning approvals for the NSW – Western Section of EnergyConnect and Victorian Section. ElectraNet is responsible for obtaining environmental planning approval for the section of EnergyConnect located in SA.

1.1.1 Proposal objectives

The primary objective for EnergyConnect (which the proposal comprises an extensive component of) is to reduce the cost of electricity by providing secure electricity transmission between NSW and SA in the near term and facilitate the longer-term transition of the energy sector across the NEM to low emission energy generation sources. More specifically, EnergyConnect (including the proposal) aims to:

- lower power prices
- improve energy security
- increase economic activity
- support the transition to a lower carbon emission energy system
- support a greater mix of renewable energy in the NEM.

Figure 1-1 Overview of EnergyConnect

1.2 The Proposal

Transgrid is seeking approval under Division 5.2, Part 5 of the *Environmental Planning and Assessment Act 1979* (the EP&A Act) to construct and operate the proposal. The proposal has been declared as Critical State significant infrastructure under Section 5.13 of the EP&A Act.

The proposal was also declared a controlled action on 30 September 2020 and requires a separate approval under the (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The proposal is subject to the bilateral assessment process that has been established between the Australian and NSW governments.

1.3 Proposal overview

1.3.1 Hydrology and flooding study area

The hydrology and flooding study area for this assessment is defined as the catchment areas of the Murrumbidgee River and the Lower Murray River that the proposal is located within and includes all minor watercourses within these catchments.

It has been applied to identify the constraints nearby to the proposal which may or may not be indirectly impacted by the proposal from a hydrological perspective. Proposed access tracks (outside of those that propose to utilise public roads) would generally be located within the hydrology study area.

The hydrology and flooding study area is located in regional western NSW across a number of Local Government Areas (LGAs), comprising the following: Wentworth Shire; Balranald Shire; Murray River; Edward River; Hay Shire; Murrumbidgee; Federation; Lockhart Shire; and Wagga Wagga LGAs.

1.3.2 Key proposal features

The key components of the proposal include:

- about 375 kilometres of new 330 kilovolt (kV) double circuit transmission line and associated infrastructure between the Buronga substation and the proposed Dinawan 330kV substation
- connection of the proposed transmission lines to the existing Buronga 330kV substation
- construction of a new 330kV substation around 30 kilometres south of Coleambally, referred to as the proposed Dinawan 330kV substation
- connection of the proposed transmission lines to the proposed Dinawan 330kV substation
- about 162 kilometres of new 500 kilovolt (kV) double circuit transmission line and associated infrastructure between the proposed Dinawan 330kV substation and the existing Wagga Wagga substation at Wagga Wagga, NSW
- upgrade and expansion of the Wagga Wagga substation to accommodate the new transmission line connections including the installation of new line bays, relocation and upgrade of existing bays and associated electrical and civil works (road, kerb, gutter, drainage works and earthworks)
- provision of three optical repeater structures and associated connections to existing local electrical supplies
- new and/or upgrade of access tracks as required
- ancillary works required to facilitate the construction of the proposal (e.g. laydown and staging areas, concrete batching plants, brake/winch sites, site offices and accommodation camps).

An overview of the proposal is provided in Figure 1-2. Further detail on the key infrastructure components of the proposal and construction activities are provided in Chapter 5 and Chapter 6 of the main EIS document respectively.

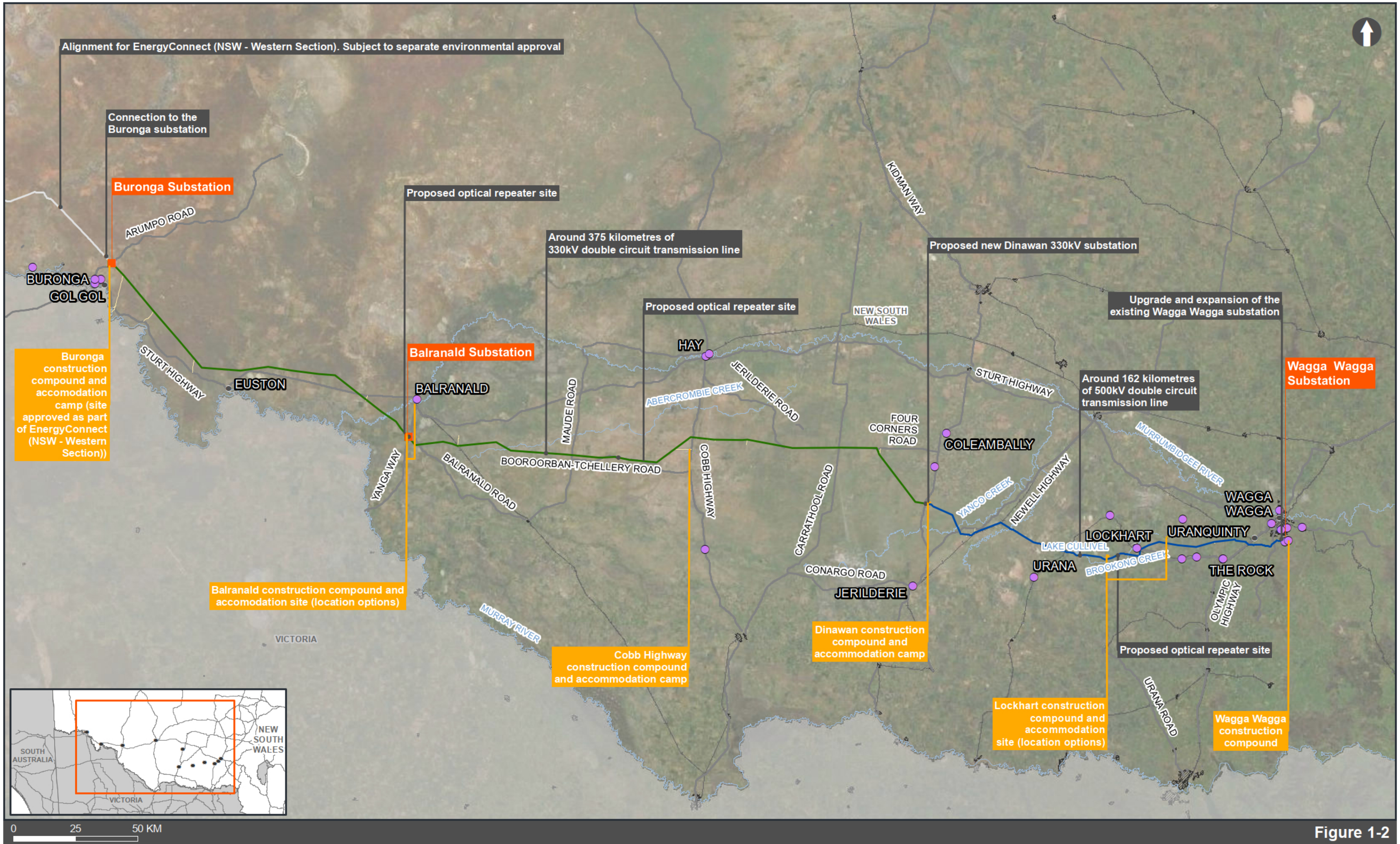

Figure 1-2

Proposal Overview - EnergyConnect (NSW - Eastern section)

- EnergyConnect (NSW - Eastern Section) 330kV transmission line
- EnergyConnect (NSW - Eastern Section) 500kV transmission line
- EnergyConnect (NSW - Western Section)
- Main Construction Compounds and Accomodation Sites
- Access Tracks
- Water Fill Point
- Existing Substation
- Built Up Areas
- Waterbody

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Source: NSWSS, ESRI, Transgrid, WSP

1.3.3 Construction

1.3.3.1 Key construction works

Key construction works for the proposal would typically include (but not be limited to):

- site establishment works, which may include (but not be limited to):
  - establishment of construction site(s), access tracks and service relocations
  - vegetation clearance
  - transportation of equipment such as steelwork, high voltage plant, switchgear, between dock and site as part of the construction works
- ancillary works to facilitate the construction of the proposal (e.g. laydown and staging areas, concrete batching plants, brake/winch sites, site offices and accommodation camps)
- construction of the proposed transmission lines, which would include (but not be limited to):
  - access tracks to accommodate safe access of construction machinery and materials to each transmission line tower site
  - earthworks (including establishment of construction pads) and the construction of footings and foundations for each transmission line tower
  - erection of the new transmission line towers using crane(s) and or helicopter(s)
  - stringing of the conductors and overhead earth wires and optical ground wire
  - installation of earthing conductors
  - testing and commissioning of the transmission lines
- construction of the proposed Dinawan 330kV substation, which would include (but not be limited to):
  - civil construction works including earthworks
  - slab construction at the new substation site
  - electrical fit out with new substation equipment
  - testing and commissioning of the new substation equipment
- upgrade and expansion of the existing Wagga Wagga substation to enable the proposed connection and operation of the new transmission lines which would include (but not be limited to):
  - civil construction works including earthworks and slab construction at the expanded substation site
  - electrical fit out with new substation equipment
  - testing and commissioning of the new substation equipment
  - connection of the proposed transmission lines to the existing Buronga substation
  - demobilisation and remediation of areas disturbed by construction activities.

A detailed description of construction works for the proposal is further described in Chapter 6 of the main EIS document.

1.3.3.2 Construction program

Construction of the proposal would commence in late-2022 (enabling works phase), subject to NSW Government and Commonwealth planning approvals.

The construction of the transmission lines and substation facilities would take around 18 months. The upgraded Wagga Wagga substation and proposed Dinawan 330kV substation are expected to be operational by late-2024. Site decommissioning and remediation would extend around six months beyond the commissioning (operational) phase, with estimated completion mid-2025.

The final program would be confirmed as part of finalisation of the proposal infrastructure following approval of the proposal.

1.3.3.3 Indicative duration of transmission line construction activities

Construction at each transmission line tower would be intermittent and construction activities would not occur for the full duration at any one location. Figure 1-3 presents an indicative duration of construction activities associated with the transmission line towers. These durations could vary and breaks between activities may be shorter which may lead to longer inactive periods in subsequent stages of construction at an individual transmission line tower. Durations of any particular construction activity, and respite periods, may vary for a number of reasons including (but not limited to), multiple work fronts, resource and engineering constraints, works sequencing and location.

These activities would also have multiple work fronts, therefore (for example) foundation works or tower erection would be occurring in several locations along the transmission line easement at the same time.

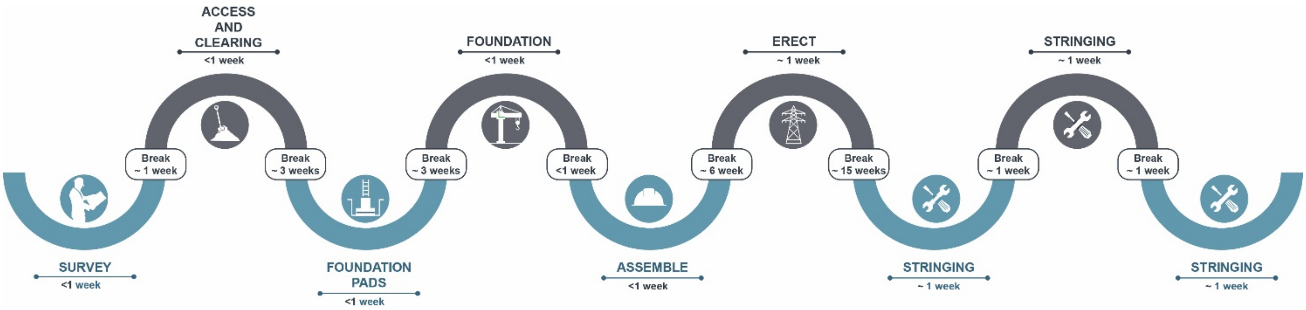


Figure 1-3 Indicative duration of construction activities at transmission line towers

1.4 Purpose of this technical report

This technical paper is one of a number of technical papers that form part of the EIS for the proposal.

The purpose of this technical paper is to identify and assess the potential impacts of the proposal in relation to surface water including flooding, water quality, water supply and geomorphology. It responds directly to the Secretary's environmental assessment requirements (SEARs) (refer to Section 1.4.1) and has been prepared with consideration of the Murray Darling Basin Plan 2012.

This report has the following objectives:

- identify the existing hydrological, geomorphic and water quality conditions within the hydrology and flooding study area
- identify key risks to hydrology, water quality and sensitive receivers in the study area as a result of the construction and operation of the proposal, and
- recommend mitigation and management measures to minimise impacts to the hydrology, flooding and water quality of the receiving environment.

1.4.1 Secretary's environmental assessment requirements

The NSW Department of Planning, Industry and Environment (DPIE) has provided the SEARs for the EIS. The requirements specific to this assessment and where these aspects are addressed in this technical report are outlined in Table 1-1.

Table 1-1 Secretary's Environmental Assessment Requirements – hydrology and flooding

REFERENCE	SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS	SECTION OF REPORT WHERE ADDRESSED
Water	an assessment of the impacts of the project on the quantity and quality of the region's surface water resources, including the Murray River, Darling River, Murrumbidgee River, having regard to NSW Water Quality Objectives	Section 5.2, 5.3 5.4, 6.3 and 6.4 (noting the project does not cross the Darling River or any part of its catchment and therefore this river has not been considered)
	details of water requirements, supply arrangements and wastewater disposal arrangements for construction and operation	Section 5.3 and 6.3
	an assessment of the impacts of the project on groundwater aquifers and groundwater dependent ecosystems having regard to the NSW Aquifer Interference Policy and relevant Water Sharing Plans; and	Addressed in Technical Paper 15 (Groundwater)
	an assessment of the potential flooding impacts and risks of the project;	Section 5.1, 5.2, 6.1, 6.2

1.5 Structure of this report

The structure and content of this report is as follows:

- *Chapter 1 – Introduction:* Outlines the background and need for the proposal, and the purpose of this report.
- *Chapter 2 – Legislative and policy context:* Provides an outline of the key legislative requirements and policy guidelines relating to the proposal.
- *Chapter 3 – Methodology:* Provides an outline of the methodology used for the preparation of this technical paper.
- *Chapter 4 – Existing environment:* Describes the existing surface water catchment, including surface water resources, water quality and flooding environment.
- *Chapter 5 – Assessment of construction impacts:* Describes the potential construction impacts associated with the proposal.
- *Chapter 6 – Assessment of operational impacts:* Describes the potential operational impacts associated with the proposal.
- *Chapter 7 – Cumulative impacts:* Outlines the potential cumulative impacts with respect to other known developments within the vicinity of the proposal.
- *Chapter 8 – Mitigation measures:* Outlines the proposed mitigation measures for the proposal.
- *Chapter 9 – Conclusion:* Provides a conclusion of the potential impacts of the proposal on the surface water environment.
- *Chapter 10 – Limitations statement: provides the limitations relevant to the report.*
- *Chapter 11 – References*: Identifies the key reports and documents used to generate this report.

1.6 Limitations

The preparation of this technical report has been a desktop exercise that has relied upon information from the proponent and freely available reports and existing investigations. The impact assessment is limited to a qualitative assessment which is based upon the concept design and proposed construction schedule at the time of preparation of this report.

The assessment undertaken to inform this technical report is adequate to assess typical environmental impacts and provide recommendations for mitigation measures. Recommendations would be subject to refinement as the proposal progresses through the ongoing refinement of the final location of the proposal infrastructure and validation is undertaken during construction.

2 Legislative and policy context

2.1 Commonwealth legislation

2.1.1 *Environment Protection and Biodiversity Conservation Act 1999*

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is administered by the Australian Department of the Agriculture, Water and the Environment and provides a legal framework to protect and manage nationally important flora, fauna, ecological communities and heritage places defined as 'matters of national environmental significance' (MNES).

Under the EPBC Act, proposed actions (i.e. activities or proposals) with the potential to significantly impact matters protected by the EPBC Act must be referred to the Australian Minister for the Environment to determine whether they are controlled actions, requiring approval from the Minister.

For this hydrology and flood study there are no impacts to MNES or the environment of Commonwealth land as part of the proposal.

2.1.2 *National Water quality Management Strategy*

The *National Water Quality Management Strategy* (Australian Government 2018) has been developed by the Australian and New Zealand governments in cooperation with state and territory governments. Endorsed by the Australian and New Zealand Environment and Conservation Council (ANZECC), the strategy establishes objectives to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development.

The *National Water Quality Management Strategy* includes guidelines for protection of water resources across Australia. These guidelines have been used to determine the existing condition of rivers and water quality objectives for the proposal.

2.1.3 *Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)*

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018) is a key guideline within the NWQMS that is used to identify catchment and waterway specific water quality management goals. These guidelines are an updated version of the previous guidelines referred to as the ANZECC 2000 guidelines.

The ANZG 2018 guidelines provide a process for assessing existing water quality conditions and developing water quality objectives to sustain current or likely future community values for water resources. Default guideline values for parameters are provided for different community values as generic starting points for assessing water quality where site specific information is not available. The default guideline values are used to evaluate the existing water quality conditions against long term water quality goals.

The ANZG 2018 guidelines provide the most up to date databases to derive guideline values for toxicants and sediments in aquaculture and aquatic foods, physical and chemical stressors and guideline values for agricultural water users. Where the ANZG 2018 does not provide a value, the values as used in the previous ANZECC 2000 guidelines still apply.

The default guideline values have not been designed for direct application in activities such as discharge licences, recycled water quality or stormwater quality. These values are provided for various levels of protection of waterways which are considered when describing the existing water quality and key indicators of concern. The level of protection applied in this assessment when assessing ambient water quality is for slightly disturbed to moderately disturbed ecosystems.

2.2 State Legislation

2.2.1 Environmental Planning and Assessment Act 1979

The *NSW Environmental Planning and Assessment Act 1979* (EP&A Act) provides a framework for environmental planning and assessment in NSW. The proposal is State Significant Infrastructure (SSI) in accordance with Division 5.2, Part 5 of the EP&A Act and requires the approval of the NSW Minister of Planning and Public Spaces (or their delegate).

In accordance with section 5.16 of the EP&A Act, the Secretary's environmental assessment requirement's (SEARs) were issued for the proposal on 5 December 2019. The SEARs were re-issued on the 31 July 2020. The SEARs required that the proposal consider potential impacts to water quality associated with construction and operation of the proposal. The SEARs relevant to this assessment are included in Section 1.4.1.

2.2.2 Water Management Act 2000

The *Water Management Act 2000* (WM Act) recognises the need to allocate and provide water for the environmental health of our rivers and groundwater systems, while also providing licence holders with access to water. The WM Act focuses on protecting, enhancing and restoring water resources and encouraging best practice management and use of water.

Section 89 of the WM Act relates to water use approvals and Section 90 relates to water management works approvals. There are three kinds of water management work approvals, namely, water supply work approvals, drainage work approvals and flood work approvals.

Under Section 91 of the WM Act a controlled activity approval is required for certain types of developments and activities that have the potential to affect water quality that are carried out at a specified location in, on or under waterfront land.

However, under section 5.23 of the EP&A Act, a water use approval, water management works or an activity approval (including a controlled activity approval) under sections 89, 90 and 91 of the WM Act are not required for State significant infrastructure. The design and construction of the proposal would consider the NSW DPIE – Water guidelines for controlled activities on waterfront land to enable the mitigation of potential impacts to water quality.

2.2.2.1 Water sharing plans

Water sharing plans are established under the WM Act and are the primary tool for defining water-sharing arrangements in NSW. The plans establish rules for sharing water between water users and the environment, and rules for water trading. Water sharing plans describe the annual surface and groundwater recharge volumes for each identified water source and the volumes of water that are available for sharing. Available water volumes are based on calculated long-term average annual extraction limit (LTAAEL). Provisions are made for environmental water allocation, basic landholder rights, domestic and stock rights and native title rights. Water sharing plans are typically in place for ten years, however they may be suspended in times of severe water shortages.

Due to the MDBA bilateral agreement multiple new water sharing plans have commenced across NSW, even though the corresponding Basin Plan Water Resource Plans (WRPs) have not been accredited (refer to Section 2.4.1). Since the update to certain water sharing plans in July 2020, four water sharing plans covering surface water are in force within the hydrology and flooding study area (NSW DPIE, 2020a). These plans are the NSW Murray and Lower Darling Regulated Rivers Water Sources 2016 plan, the Lower Murray-Darling Unregulated River Water Source 2011 plan, the Murrumbidgee Regulated River Water Source 2016 and Murrumbidgee Unregulated River Water Source 2012.

All the plans are currently under review to ensure compliance with the Basin Plan (2012). Currently the plans are either awaiting assessment from the MDBA, final amendments or Australian Government accreditation.

2.2.3 *Protection of the Environment Operations Act 1997*

The *Protection of the Environment Operations Act 1997* (PoEO Act) establishes, amongst other things, the procedures for issuing licences for environmental protection on aspects such as waste, air, water and noise pollution control. An environment protection licence (EPL) is required under Chapter 3 of the POEO Act to undertake a scheduled activity or scheduled development work.

The proposal would include a proposed screening plant as part of the earthworks to occur at the proposed Dinawan 330kV substation site. Crushing, grinding or separating is listed as scheduled activity 16 under the Schedule 1 of the Protection of the Environment Operations Act 1997 (POEO Act):

> *16 Crushing, grinding or separating*
>
> *(1) This clause applies to crushing, grinding or separating, meaning the processing of materials (including sand, gravel, rock or minerals, but not including waste of any description) by crushing, grinding or separating them into different sizes.*
>
> *(1A) However, this clause does not apply to the processing of materials by crushing, grinding or separating that occurs as part of an activity that is declared to be a scheduled activity by—*
>
> *(a) clause 33 (Railway activities—railway infrastructure construction), or*
>
> *(b) clause 35 (Road construction).*
>
> *(2) The activity to which this clause applies is declared to be a scheduled activity if it has a capacity to process more than 150 tonnes of materials per day or 30,000 tonnes of materials per year.*

Based on the currently proposed screening daily rates (up to around 150,000 to 200,000 cubic metres of total volume), criteria (2) would be exceeded and the proposed screening activities would trigger the need for an EPL.

Section 5.24(e) of the EP&A Act identifies approvals or authorisations that cannot be refused if they are necessary for carrying out approved SSI (or critical SSI) and are substantially consistent with the Part 5.2 approval, including the need for:

- an environment protection licence under Chapter 3 of the *Protection of the Environment Operations Act 1997* (for any of the purposes referred to in section 43 of that Act).

2.3 NSW Water Quality Objectives

The NSW Water Quality and River Flow Objectives (Office of Environment and Heritage, 2006) (NSW WQO) are the agreed community values and long-term goals for NSW's surface waters. The NSW WQO set out:

- the community's values and uses for rivers, creeks, estuaries and lakes (i.e. healthy aquatic life, water suitable for recreational activities like swimming and boating, and drinking water); and
- a range of water quality indicators to help assess the current condition of waterways and whether they support those values and uses.

The proposal is located in the Barwon-Darling and Far Western, Murray and the Murrumbidgee catchments under the NSW WQO classifications, however the NSW WQO state that the Murray-Darling Basin Commission (and now the Basin Plan 2012) supersedes the NSW WQO for the hydrology and flooding study area.

2.4 Basin Plan 2012

The Murray–Darling Basin Plan (the Basin Plan 2012) aims to provide a coordinated approach to water use across the Murray–Darling Basin's four states and the ACT. It provides a framework to balance environmental, social and economic considerations for water use and water quality to an environmentally sustainable level. The Plan addresses both surface and groundwater use and water quality. Elements of the plan include:

- overall environmental management objectives and outcomes
- sustainable diversion limits (SDL) – on how much surface water and groundwater can be taken from the Basin and a mechanism for adjustments to these limits
- an environmental watering plan – to protect and restore the Basin's rivers and wetlands
- a water quality and salinity management plan that sets objectives and targets
- identifying the risks to continued water availability in the Basin, and strategies to manage them
- a monitoring and evaluation program, including an annual report on the effectiveness of the Basin Plan.

The overarching objective for the Basin Plan 2012 in regard to water quality and salinity is to maintain appropriate water quality, including salinity levels, for environmental, social, cultural and economic activity in the Murray-Darling Basin. The Basin Plan 2012 sets water quality targets and objectives to protect water quality in the Basin's rivers for people and livestock as well as for wetlands and floodplains. The Basin Plan requires water managers to consider water quality targets when making decisions about environmental watering and running the river.

The State of the Environment (SoE) 2012 report demonstrated that there was little relationship between standard water quality targets and aquatic ecosystem health, due to the highly variable nature of natural water quality regionally (see the discussion under 'Water quality by river valley' in the Water quality section of SoE 2012). This highlighted a need for regional guidelines to be established, reflecting the natural regional variability noted.

The Basin Plan 2012 (Schedule 11) outlines water quality zones (also referred to as target application zones) and provides water quality targets which are used to assess water quality at inland monitoring stations. These replace the previous default trigger values for slightly disturbed ecosystems listed in the National Water Quality Management Strategy and are reproduced in the water resource plans for each sub-catchment of the Murray Darling Basin along with water quality objectives for each catchment. These water quality objectives contribute to the overall water quality objective for the Murray-Darling Basin to maintain appropriate water quality, including salinity, for environmental, social, cultural, and economic activity and provide a context for the management of surface water quality from the proposal.

2.4.1 Water Resource Plans

The Basin Plan 2012 requires the preparation of water resource plans (WRP). The water resource plans set rules on how much water can be taken from the Basin, ensuring that the sustainable diversion limit is not exceeded over time. The Murray-Darling Basin Authority (MDBA) is responsible for monitoring and enforcing compliance with water resource plans. NSW submitted all 20 WRPs (11 groundwater and 9 surface water resource plans) to the MDBA for assessment, in the first half of 2020. The MDBA and NSW have agreed to a new bilateral agreement that will cover the 2020–21 water year as the NSW WRPs were not accredited before 1 July 2020. The proposal would be governed by the following WRPs:

- NSW Murray and Lower Darling surface water resource plan
- Murrumbidgee River surface water resource plan.

The water resource plans provide water quality management plans to support water quality management within the catchments. The plans include water quality objectives as shown in Table 2-1. These values form part of a broader framework to protect, improve and restore water quality.

Table 2-1 NSW Murray and Lower Darling water resource plan and Murrumbidgee water resource plan water quality objectives

BASIN PLAN WATER QUALITY OBJECTIVE	DESCRIPTION	BASIN PLAN REFERENCE
Maintain water quality to protect First Nations people's water dependent values and uses	The objective is to ensure water quality is sufficient to maintain the spiritual, social, customary and economic values and uses of water by First Nations people	10.52
Maintain water quality to protect and restore water quality dependent ecosystems	The objective is to ensure water quality is sufficient to: — protect and restore ecosystems and ecosystem functions — ensure ecosystems are resilient to climate change — maintain the ecological character of Ramsar wetlands.	9.04
Maintain the quality of raw surface water for treatment for human consumption	The objective is to minimise the risk that the quality of raw water taken for human consumption results in: — adverse human health effects — the odour of drinking water being offensive to consumers — the objective also aims to maintain the palatability of rating of drinking water at the level of good as set out in the Australian Drinking Water Guidelines.	9.05
Maintain the quality of surface water for irrigation use	The objective is to ensure the quality of surface water, when used in accordance with the best irrigation and crop management practices and principles of ecologically sustainable development, does not result in crop yield loss or soil degradation. This objective applies at sites where water is extracted by an irrigation infrastructure operator for the purpose of irrigation (see Section 4.1).	9.06
Maintain the quality of surface water for recreational use	The objective ensures a low risk to human health from water quality threats posed by exposure through ingestion, inhalation or contact during recreational use of NSW Murray and Lower Darling Water resources	9.07
Maintain good levels of water quality	The objective is to maintain the value of a water quality characteristic if it is at a level that is better than the target value set out in Section 6.	9.08

The water resource plans identify water quality zones within their jurisdiction. Water quality targets are then provided for each water quality zone as shown in Table 2-2. The Basin Plan 2012 and water resource plans provide values for Ramsar declared wetlands and 'Other water dependent ecosystems' which covers all other waterbodies, streams and rivers. Table 2-2 shows the water quality targets for 'Other water dependent ecosystems' for the water quality zones in the relevant water resource plans.

Table 2-2 Water quality targets under the Basin Plan 2012 for 'Other water dependent ecosystems' for the water quality zones in the relevant water resource plans

WATER QUALITY ZONE	TURBIDITY (NTU) (ANNUAL MEDIAN)	PH	TOTAL NITROGEN (UG/L)	TOTAL PHOSPHORUS (UG/L)	DISSOLVED OXYGEN (MG/L; OR % SATURATION) (ANNUAL MEDIAN)	PESTICIDES, HEAVY METALS AND OTHER TOXIC CONTAMINANTS[1]
Darling Valley, Middle lower (Dml)	50	6.5–8	500	50	85–110%	the protection of 95% of species
Lower Central Murray (cMl)	35	6.5–8	700	80	>8 mg/L or 90–110%	the protection of 95% of species
Castlereagh, Lachlan, Macquarie and Murrumbidgee (A3)	35	6.5–8	600	50	>7 mg/L or 60–110%	the protection of 95% of species
Upper and Middle Central Murray (cMum)	15	6.5–7.5	500	40	>7.7 mg/L or 90–110%	the protection of 95% of species
Lowland Castlereagh, Lachlan, Macquarie and Murrumbidgee (B3)	20	7.0–8.0	600	35	>8 mg/L or 90–110%	the protection of 95% of species

(1) Refer to values in table 3.4.1 of the ANZECC Guidelines (Must not be exceeded)

Electrical conductivity targets are not described for each water quality zone of the Basin Plan. Instead, the Murray-Darling Basin End-of-Valley salinity targets are incorporated into the water quality targets. The NSW End-of-Valley targets are listed in Table 2-3.

Table 2-3 Salinity (electrical conductivity) End-of-Valley targets under the New South Wales Murray and Lower Darling water resource plan and Murrumbidgee water resource plan

WATER QUALITY ZONE	SALT LOAD PER YEAR (T/YR)	END OF VALLEY TARGETS (ABSOLUTE VALUE)	
		Median (50%ile) – EC, µS/cm	Peak – EC µS/cm
Murray			
Darling Valley, Middle lower (Dml)	576,400	389	453
Upper and Middle Central Murray (cMum)	–	–	412
Lower Central Murray (cMl)	–	–	412
Murrumbidgee			
Castlereagh, Lachlan, Macquarie and Murrumbidgee (A3)	169,600	162	258
Lowland Castlereagh, Lachlan, Macquarie and Murrumbidgee (B3)	169,600	162	258

2.5 Other policy and guidelines

The following table summarises guidelines relevant to the design, assessment and management of surface water resources for the proposal.

Table 2-4 Summary of relevant guidelines

AUTHORITY	NAME	DESCRIPTION
Commonwealth, Australian Institute for Disaster Resilience	Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia, Handbook 7, 2017	This guide prepared by the Australian Institute for Disaster Resilience (AIDR) has been developed to provide guidance on the national principles supporting disaster reliance in Australian through the management and publication of this Handbook and others for other types of hazards. This Handbook is supported by six additional guidelines that cover specific aspects of flood risk management and a practice note to assist with land use planning. This Handbook has been considered when developing criteria for managing flood risk from the proposal and compliments the NSW Floodplain Development Manual (DIPNR 2005) by outlining current best practices for flood risk management.

AUTHORITY	NAME	DESCRIPTION
NSW, Department of Natural Resources	NSW Government's Floodplain Development Manual, 2005	This is the NSW Government's Manual relating to the management of flood liable land in accordance with Section 733 of the *Local Government Act 1993*. The manual supports the NSW Government's Flood Prone Land Policy in providing for the development of sustainable strategies for managing human occupation and use of the floodplain. The manual applies to floodplains across NSW, in both urban and rural areas. It is also used to manage major drainage issues in local overland flooding areas.
NSW, Office of Environment and Heritage	Floodplain Risk Management Guide Incorporating 2016 ARR in studies, 2018	This guide provides advice on incorporating changes with recent updates to Australian Rainfall and Runoff (ARR) to flood risk management in NSW.
NSW, Department of Primary Industries	Guidelines for controlled activities on waterfront land, 2012	Provide guidance on development and activities on waterfront land.
NSW, Office of Environment and Heritage	Guidelines for developments adjoining land and water, 2013	Managed by the Department of Environment, Climate Change and Water it provides guidance on development and activities on waterfront land.
Landcom	The Managing Urban Stormwater – Soils and Construction, 2004	These are aimed at providing guidance for managing soils in a manner that protects the health, ecology and amenity of urban streams, rivers estuaries and beaches through better management of stormwater quality. They provide best practice guidelines, principles, and recommended minimum design standards for good management practice in erosion and sediment control during construction works. Of particular relevance to the proposal is Volume 1, 4th Edition (commonly known as The Blue Book).
NSW State Emergency Service	Local Flood Plans for all relevant councils	The plan sets out the flood emergency management arrangements for the LGA of Wentworth. The plan includes preparation, response and recovery procedures for managing a flood emergency for the Murray and Darling River floodplains. The plan also includes a brief understanding of the existing flood risk for the LGA.
All relevant councils (Wagga Wagga, Lockhart, Federation, Murrumbidgee, Hay, Edward River, Murray River, Balranald, Wentworth)	Flood Prone Land Policy, 2017	The purpose of the policy is to guide all types of development on the floodplain with due regard to flood levels, flood scour damage, restriction to the floodplain, effect on flood flow and other socio-economic factors.

3 Methodology

3.1 Overview

The hydrology and flooding study area for this assessment is defined as the catchment areas of the Murrumbidgee River and the Lower Murray River that the proposal is located within and includes all minor watercourses within these catchments.

The proposed methodology for the hydrology and flooding impact assessment included considering all surface water resources such as permanent and intermittent; rivers, creeks, dams, lakes and any other features that either store, transport or use surface water. The proposed methodology has been separated into aspects that can be considered separately but as a whole inform the complete understanding of surface water resource. These separable aspects for assessment include:

- flooding impact assessment
- geomorphologic impact assessment
- water quantity – impact assessment including long term impacts to catchment health
- water quality impact assessment.

A qualitative approach to the impact assessment has been adopted. This approach is deemed appropriate to assess typical environmental impacts from the numerous transmission structures which would support the transmission line, the proposed Dinawan 330kV substation, the upgraded and expanded Wagga Wagga substation and associated typical construction activities.

The proposed methodology for each aspect of the surface water environment is presented in Sections 3.2 to 3.5.

3.2 Flooding

A qualitative assessment was carried out to understand existing flood behaviour in the hydrology and flooding study area and to assess potential impacts to flooding, and flood risks to the proposal. This involved:

- a desktop review of historic flood information to understand the health of waterways and flood risks across the study area
- a review of the preliminary flood risk assessments for the study area (refer to Appendix A). This was completed by Beca and was carried out to quantify the flood risk for the proposal
- a qualitative assessment of potential impacts to, or from, flooding behaviour based on an understanding of the existing flooding environment, construction methodology and proposal design
- identifying mitigation and management measures to minimise flood risk to, or caused by, the proposal. These include design features, management plans and monitoring.

3.2.1 Review existing flood information

This task included a desktop review of existing flood studies, Bureau of Meteorology (BOM) flood gauge data, NSW Water stream flow data, Balranald, Murray River, Hay, Edward River, Murrumbidgee, Federation, Lockhart and Wagga Wagga Council flood information, historic flood event aerial photography and newspaper articles on flood events. In addition, the State Emergency Services (SES) flood data portal was accessed to gather flood intelligence for the flooding and hydrology study area.

It is acknowledged that there was limited information available on flooding away from the Murrumbidgee River and as such no flood information was available from the Balranald, Murray River, Hay, Edward River, Murrumbidgee and Federation Councils across the project corridor.

The existing data has then been used to understand existing flooding conditions across the proposal area. This has included inferring flood extents based on historic flood photos and anecdotal information from newspaper articles. The flood information has been mapped where available, but it is largely unavailable in a geospatial format and therefore interpretation of images and text descriptions of flood behaviour has been the main approach to presenting the information.

3.2.2 Preliminary flood risk assessment

A preliminary flood risk assessment was completed for the proposal to understand the existing flood risk in the proposal area (Beca 2020). The methodology for the flood risk assessment was as follows:

- a 400 metre grid resolution was adopted for the topographic conditions, based upon Hydrologically Enforced Shuttle Radar Topography Mission (SRTM) data which forms the only project-wide dataset available (the 400 metres by 400 metres grid provides interpretation of the topography that can be used for the flood risk assessment)
- the hydrologic assessment converts the rainfall across the study area to flows across the study area and adopted the following parameters:
  - the 400-metre grid data was used to define the Darling River and Darling Anabranch catchments
  - an 1% Annual Exceedance Probability (AEP) design rainfall (i.e. a single design flood) was assessed
  - the 24 hours storm duration was assessed using a single representative temporal pattern across the catchment
- the hydraulic assessment converts the flows to flood depths and velocities across the study area and adopted the following method:
  - a two-dimensional hydraulic model was built using the 400 metre grid topographic data
  - the 1% AEP flows generated for the hydrologic assessment were input into the hydraulic model
  - the model was then checked against stream flow and water level gauge information of the Murray River, Darling River and Murrumbidgee River, and relevant surrounding gauges, and designated (2012) CSIRO flood extents, to ensure that major flowpaths were defined by the model and therefore deemed the model fit for purpose
  - outputs from the hydraulic flood risk assessment were:
    - values for the maximum depth, maximum velocity and maximum simple hazard in the 1% AEP
    - point values for the maximum depth, maximum velocity and maximum simple hazard in the 1% AEP event at tower locations.

The limitations of the assessment were:

- the SRTM data is a global terrain dataset captured via the Space Shuttle Endeavour as part of an international effort to develop global digital elevation models. Random sampling of the SRTM data through spot tests conducted by Beca (2020) demonstrated that within the project corridor this vertical accuracy is closer to ± seven to eight metres vertically, relative to Light Detection and Ranging (LiDAR) elevation information
- the 400 metre modelling grid may not capture actual terrain levels and other geographical features and a vertical buffer of ± three metres is recommended to be applied to the flood depths produced from the flood risk assessment
- the assessment was prepared for the purpose of a classification of the flood risk to the proposed transmission alignment and associated towers.

3.2.3 Impact assessment

A qualitative assessment for identifying the impact of the construction and operation of the proposal to flood behaviour has been completed. This has involved overlaying the hydrology and flooding study area over available flood information and identifying qualitative changes to flood behaviour, including changes to flood extents and flood velocities. Changes to flood depths and flood duration could not be adequately assessed due to the preliminary design of the proposal. The assessment also considered potential changes to flood behaviour for structures, such as buildings and infrastructure (predominantly roads) in the floodplain.

3.2.4 Flood mitigation and management

Where the proposal is deemed to have an impact to flood behaviour, mitigation measures and long-term management actions have been recommended. Management measures have included management of the flood risk to the proposal to minimise damage and speedup recovery to the proposal infrastructure following a flood event and changes to flood risk as a result of the proposal.

3.3 Geomorphology

Geomorphology relates to the form, shape, size and structure (slopes, presence of rocks, locations of ponds, soil types) of watercourses. The geomorphic condition of a watercourse is dependent on the flows, vegetation, soil types, aquatic biodiversity etc and these can be affected by human induced changes to catchments and watercourses. Watercourses in good geomorphic condition are important for overall catchment health.

The NSW River Styles mapping (NSW Department of Industry, 2019) has also been used for this assessment. The geomorphic assessment has focussed on locations where hydrology and flooding study area crosses waterways. Waterways included in this assessment are noted in Section 4.1 and shown in Figure 4-1.

The geomorphology impact assessment has included:

- review of the existing fragility of the waterways
- qualitative assessment of the potential changes to existing geomorphic dependent actions, including flows
- identification of mitigation and management measures to minimise impacts to the surface water features.

3.4 Water supply and water resources

The water supply, water storage and water demands of the existing environment as well as understanding the potential water demands of the proposal has been assessed. The understanding of the water quantity informs the validity of water for all demands such as agriculture, industry, potable and the environment. The assessment involved:

- a desktop review of existing water supply and water storages and water sharing plans
- identification of existing environmental water requirements in the vicinity of the hydrology and flooding study area
- a review of proposed construction and operational water demands
- qualitative assessment of potential impacts to water availability for the construction and operation of the proposal
- identification of mitigation and management measures to minimise loss of available surface water.

3.5 Water quality

Water quality refers to the chemical and physical quality of the water in all surface water features for the catchment and the hydrology and flooding study area. Water quality affects all aspects of the environment and must be understood to protect the existing and future environments. The assessment involved:

- a desktop review of available previous water quality studies to determine the existing water quality baseline conditions
- identification of the water quality assessment criteria
- a comparison of the baseline to the Basin Plan Water quality objectives and targets
- a qualitative assessment of the potential pollutants and impacts to the water quality environment from construction and operation activities
- identification of mitigation and management measures to minimise impacts to water quality.

3.5.1 Desktop review

To inform an understanding of the existing environment a desktop review was carried out. The following documents and data sources were reviewed:

- *State of the Catchment* (Office of Environment and Heritage, 2010)
- National Water Quality Assessment (Sinclair Knight Merz, 2011)
- State of the Environment (EPA, 2018)
- *Darling Water Resource Plan* (Department of Primary Industries (DPI), 2018)
- *Murrumbidgee Water Resource Plan* (Department of Primary Industries (DPI), 2019)
- Basin Plan 2012 Annual report 2018–2019 (MDBA, 2020)
- WaterNSW monitoring data.

3.5.2 Water quality assessment criteria

The NSW WQO and Basin Plan 2012 provides the community values and the ANZG guidelines provide the associated water quality indicators and default guideline values (refer to Section 2.3). The following water quality parameters are commonly used as indicators of waterway health and have been adopted as the basis of this assessment:

- pH is a measure of acidity or alkalinity. Although pH can naturally vary in aquatic ecosystems depending on site-specific factors, most natural freshwater systems range from 6.5 to 8.0 pH units (ANZG 2018). pH is an important parameter to monitor as it can significantly impact the physiological processes of aquatic biota when changes to the natural pH range occur (ANZG 2018). Furthermore, it can influence the solubility of nutrients and pollutants such as metals, thereby increasing the potential for toxicity, particularly where unnaturally low pH values are observed.
- Turbidity is a measure of water clarity and is usually measured in situ (in the field) using a water quality meter. Turbidity is highly variable in river systems across Australia, with some systems being naturally more turbid than others. Hence, water quality guidelines are tailored for the different regions of Australia. Elevated turbidity can impair respiratory processes of aquatic organisms and reduce light penetration, thus affecting growth of aquatic plants.
- Nutrients are an important indicator of water quality and originate from a range of point and diffuse sources, particularly the discharge of sewage effluent and agricultural runoff (fertilisers, waste from livestock). Excessive nutrients can result in eutrophication and algal blooms, can significantly impact aquatic ecosystem health, and reduce ecological and recreational values of freshwater resources. Concentrations of total nitrogen (TN) and phosphorus (TP) were used to examine compliance with water quality guidelines.
- Electrical conductivity is a surrogate for total dissolved salts and was used in the National Water Quality Assessment 2011 as a measure of salinity. Reduction in the frequency of high flows resulting from river regulation and drought, combined with land clearing, have the potential to increase salinity in freshwater systems. Some systems are naturally saline, particularly where saline groundwater dominates, and geology and soils are high in salt content. Other factors affecting instream conductivity include evaporation and dilution during high flows arising from extensive rainfall. Evaporative losses, particularly in inland lakes, can result in concentration of salts, which is reflected in elevated conductivities. Flood events can flush salts from the landscape into waterways following prolonged drought, which can lead to an initial increase in conductivity, which may be followed by a reduction over time as a result of dilution. It is possible for levels to reach critical thresholds whereby the health of aquatic biota may be compromised.

3.5.3 Impact assessment

The qualitative assessment of the potential water quality impacts considers:

- the existing water quality environment
- the potential pollutants and impacts to the water quality environment from construction and operation activities
- the effectiveness of the identified mitigation measures
- any residual impacts post-mitigation and the likely performance against the water quality objectives.

The construction impact assessment aims to identify potential water quality impacts based on current understanding of the likely construction approach and construction methods.

The operational impact assessment identifies potential impacts to water quality during operation of the proposal.

3.5.4 Water quality mitigation measures

In addition to design guidelines and requirements, other mitigation measures are identified to minimise and manage potential impacts to waterways. The mitigation measures focus on performance outcomes that should be used to inform future stages of the design.

3.5.5 Water quality monitoring

Section 8 outlines a monitoring program to assess the performance of the proposed design and mitigation measures to meet the proposal specific criteria. The monitoring program was developed to focus on the common pollutants and complement existing historic data and monitoring programs.

4 Existing environment

4.1 Catchment overview

The proposal is located in the Murray-Darling Basin. The Murray-Darling Basin captures over one million square kilometres of land in QLD, NSW, ACT, VIC and SA. There are a number of sub-catchments within the Murray-Darling Basin (Murray Darling Basin Authority, 2020) with the proposal being located in the Murrumbidgee, Mid-Murray Peacock Creek, and Lower Darling catchments. Figure 4-1 shows catchments crossed by the proposal.

The majority of the hydrology and flooding study area is located in the Murrumbidgee catchment. The Murrumbidgee catchment is about 84,000 square kilometres (NSW DPI, 2020), about eight percent of the Murray-Darling Basin. The major river is the Murrumbidgee River which covers a length of 1,485 kilometres beginning in the Australian alps in Kosciuszko National Park flowing west to its confluence with the Murray River near Balranald. A quarter of NSW fruit and vegetable production, 42 percent of the NSW grape production and 50 percent of Australia's rice production comes from the Murrumbidgee. Annual average rainfall in the catchment ranges from over 1,600 millimetres in the cool temperate alpine regions, at an elevation up to 1,400 metres to around 350 millimetres on the semi-arid plains of western NSW, where the elevation is less than 100 metres. Most of the inflow of the catchment occurs in the Great Dividing Range.

The Lowbidgee Irrigation area located between Maude and Balranald towards the western end of the hydrology and flooding study area, covers an area of around 2,000 square kilometres of the lower Murrumbidgee River and its tributaries including the confluence of the Murrumbidgee and Lachlan Rivers. Most of the land within the floodplain is irrigated farmland.

Upstream of the Lowbidgee area is the Yanco Creek System towards the eastern end of the hydrology and flooding study area. This is an anabranch complex which links the Murrumbidgee to the Edward River through interconnected waterways including Yanco Creek, Colombo Creek, Billabong Creek and Forest Creek (NSW DPIE, 2019). These local waterways support a large number of uses and values including domestic, stock and irrigation water supply for over 180 farms, town water supply to Morundah, Urana, Oaklands, Jerilderie, Conargo and Wanganella, recreational uses such as fishing, First Nations cultural heritage and biodiversity conservation, which is administered under the Murrumbidgee Regulated Rivers Water Sources 2016 Plan (refer to Section 4.5). The Yanco Creek System supports one of two known self-sustaining populations of endangered Trout Cod.

Before river regulation was introduced, Yanco Creek only connected with the Murrumbidgee River during floods. Water is now diverted from the Murrumbidgee into Yanco Creek at the Yanco Weir and these waterways are now permanently flowing streams, with sections of still and fast flowing water, and deep and shallow water.

The Coleambally Irrigation Area is an approximate 457,000 hectare area in the Murrumbidgee which includes 516 kilometres of supply channels and 717 drainage channels. These channels supply irrigation from mid-August to mid-May and service crops including corn, cotton and rice.

About 100 kilometres of the hydrology and flooding study area between Kidman Way and County-Boundary Road is located in the Mid-Murray catchment. This catchment is about three percent of the Murray-Darling Basin and spans the border with Victoria comprising an area of 14,675 square kilometres. It includes the Murray and Edward Rivers and supports extensive areas of irrigated agriculture (pasture and crops). The proposal is located in the upper reaches of this catchment.

The western 120 kilometres, from about Waidaira Creek to Buronga is located in the Lower Darling catchment. The Lower Darling catchment is about three percent of the Murray Darling Basin, incorporating the entire local government areas (LGA) of Wentworth and Broken Hill, the majority of the Balranald LGA, a section of the Central Darling LGA and the southern portion of the Unincorporated Area (administered by New South Wales Land and Property Management Authority). The major river systems are the Darling River and the Darling Anabranch (located outside of the current hydrology and flooding study area).

There is a very small amount of run-off within this catchment and nearly all the water flowing through the Lower Darling comes from the rivers of southern Queensland and northern New South Wales through the Barwon–Darling river system. The Lower Murray Darling River systems have been modified with a weir system that is highly regulated, making it difficult to return flow to pre-development conditions. Threats to the river system include flow regulation, over extraction of water for consumptive purposes, and the construction of structures or towers that impede flooding. These threats are leading to a decline in the health of floodplain, wetland, lake and riverine ecosystems.

4.1.1 Waterways in the hydrology and flooding study area

Table 4-1 describes the named waterways and the Strahler stream order of waterways crossed by or located near the proposal sites. Table 4-1 also provides a description of the waterways.

Table 4-1 Name and stream order of waterways crossing the proposal

WATERWAY	STREAM ORDER	DESCRIPTION
Box Creek	8	Non perennial river, Lower Murray Darling catchment
Murrumbidgee River	9	Perennial river, Murrumbidgee catchment
Condoulpe Creek	2	Unknown flow characteristics, Murrumbidgee catchment
Abercrombie Creek	9	Mainly dry river, Murrumbidgee catchment
The Forest Creek	9	Mainly dry river, Murrumbidgee catchment
Curtains Creek	9	Mainly dry river, Murrumbidgee catchment
Nyangay Creek	9	Mainly dry river, Murrumbidgee catchment
Eurolie Creek	4	Mainly dry river, Murrumbidgee catchment
Bublebundie Creek	1	Mainly dry creek, Murrumbidgee catchment
Coleambally Outfall Drain	9	Unknown flow characteristics, Murrumbidgee catchment
Yellow Clay	2	Unknown flow characteristics, Murrumbidgee catchment
Yanco Creek	9	Unknown flow characteristics, Murray catchment
Colombo Creek	9	Perennial river, Murray catchment
Coonong Creek	2	Unknown flow characteristics, Murray catchment
Hallidays Cut	5	Unknown flow characteristics, Murray catchment
Brookong Creek	5 and 4	Unknown flow characteristics, Murrumbidgee catchment
Bullenbong Creek	6	Unknown flow characteristics, Murrumbidgee catchment
Burkes Creek	6	1 perenniality, Murrumbidgee catchment
Sandy Creek	6	2 perenniality, Murrumbidgee catchment
Sawpit Gully	2	2 perenniality, Murrumbidgee catchment
Crooked Creek	5	2 perenniality, Murrumbidgee catchment
Boiling Down Creek	4	2 perenniality, Murrumbidgee catchment

The Strahler stream order classification is a ‘top down’ system in which streams of the first order are the outermost tributaries. If two streams of the same order merge, the resulting stream is given a number that is one higher. If two rivers with different stream orders merge, the resulting stream is given the higher of the two numbers. Under the Strahler stream order classification, 1st to 3rd order streams are called headwater streams. Streams classified as 4th through 6th are medium streams and streams that are 7th order or larger are a river.

Named waterways that are not crossed by the proposal but that are located within the hydrology and flooding study area are Boree Creek, Stringybark Creek and Coxs Creek. Figure 4-1 shows the main watercourses for the hydrology and flooding study area. The waterways crossed include a mix of natural and manmade waterways such as canals and drains. There are other unnamed watercourses located in the hydrology and flooding study area, however these are minor and ephemeral watercourses and would not be considered sensitive receivers (refer to Section 4.14).

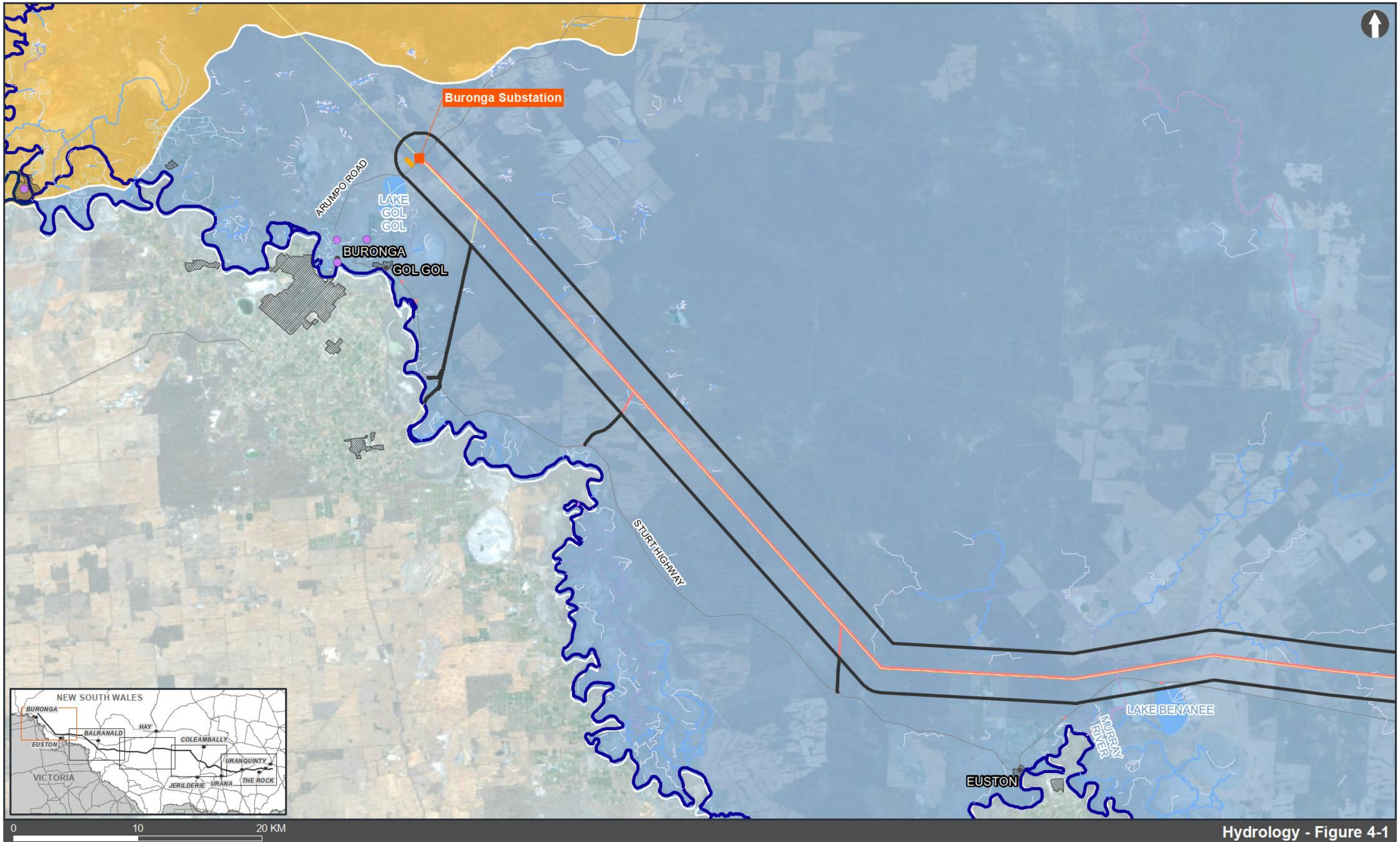
The proposal is generally located to the south of the Murrumbidgee River, only traversing the river at the western end near Balranald near its confluence with the Murray River.

The Coleambally Irrigation Area is located to the north of the hydrology and flooding study area at Coleambally to the west of Narrandera. It is a series of connected supply and drainage channels which provides irrigation to nearly 500 farms over an area of 400,000 hectares. The channels are supplied from the Murrumbidgee River and deliver between 200,00 to 300,000 mega litres a year to farms.

4.1.2 Waterbodies in the hydrology and flooding study area

Lakes and waterbodies located along the length of the proposal include Dry Lake, Lake Benee, Lake Caringay, Waldaira Lake, Condoulpe Lake, Dusty Lake, Five Tree Dam, Lake Urana, Lake Cullivel and Lake Albert.

Lake Urana is a large shallow intermittent salt lake in a depression at the end of the drainage basin of Billabong, Coonong and Urangeline creeks. It fills every ten to 20 years and retains water for several years (NSW National Parks and Wildlife Service, 2020). Lake Albert is a 125-hectare artificial lake in the suburb of Lake Albert in Wagga Wagga. The lake is used for recreational purposes including water sports, boating and fishing (Wagga Wagga City Council, 2020).



Hydrology - Figure 4-1

Waterways, Waterbodies and Catchments in the Study Area

Sheet 1 of 5

Project Components
- Construction Impact Area
- Main Construction Compounds and Accomodation Sites
- Water Fill Point
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Surface Water Study Area
- Built Up Areas
- Waterbody

Catchment Boundaries
- Darling River Basin
- Peacock Creek Basin

Strahler Stream Order
- Strahler Stream Order - 0
- Strahler Stream Order - 1
- Strahler Stream Order - 2
- Strahler Stream Order - 3
- Strahler Stream Order - 4
- Strahler Stream Order - 5
- Strahler Stream Order - 10
- Strahler Stream Order - 11

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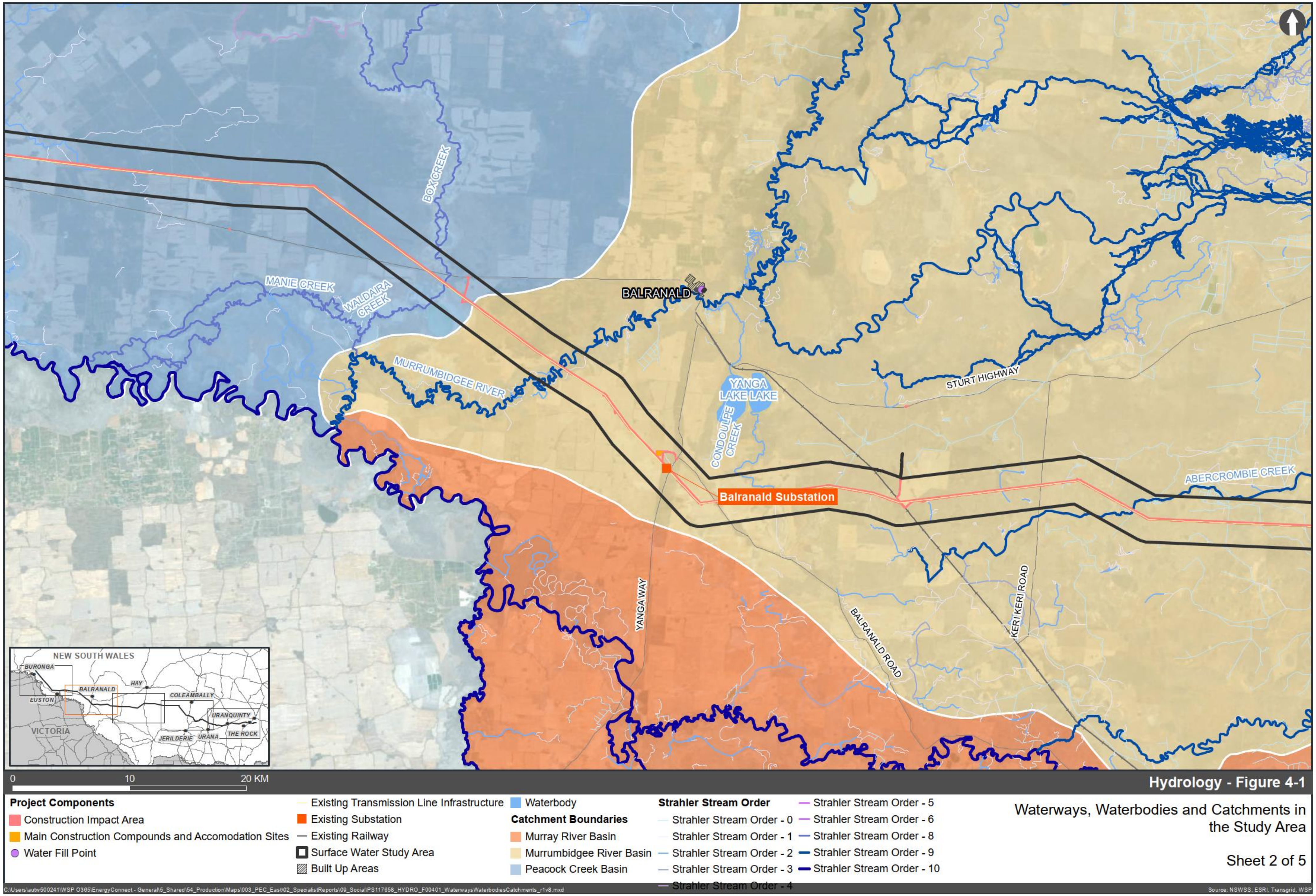
Source: NSWSS, ESRI, Transgrid, WSP


BOX CREEK
MANIE CREEK
WALDAIRA CREEK
BALRANALD
MURRUMBIDGEE RIVER
YANGA LAKE
LAKE
CONDOULPE CREEK
STURT HIGHWAY
Balranald Substation
ABERCROMBIE CREEK
YANGA WAY
BALRANALD ROAD
KERI KERI ROAD
NEW SOUTH WALES
BURONGA
BALRANALD
HAY
EUSTON
COLEAMBALLY
URANQUINTY
VICTORIA
JERILDERIE
URANA
THE ROCK
0
10
20 KM
Hydrology - Figure 4-1
Project Components
Construction Impact Area
Main Construction Compounds and Accomodation Sites
Water Fill Point
Existing Transmission Line Infrastructure
Existing Substation
Existing Railway
Surface Water Study Area
Built Up Areas
Waterbody
Catchment Boundaries
Murray River Basin
Murrumbidgee River Basin
Peacock Creek Basin
Strahler Stream Order
Strahler Stream Order - 0
Strahler Stream Order - 1
Strahler Stream Order - 2
Strahler Stream Order - 3
Strahler Stream Order - 4
Strahler Stream Order - 5
Strahler Stream Order - 6
Strahler Stream Order - 8
Strahler Stream Order - 9
Strahler Stream Order - 10
Waterways, Waterbodies and Catchments in the Study Area
Sheet 2 of 5
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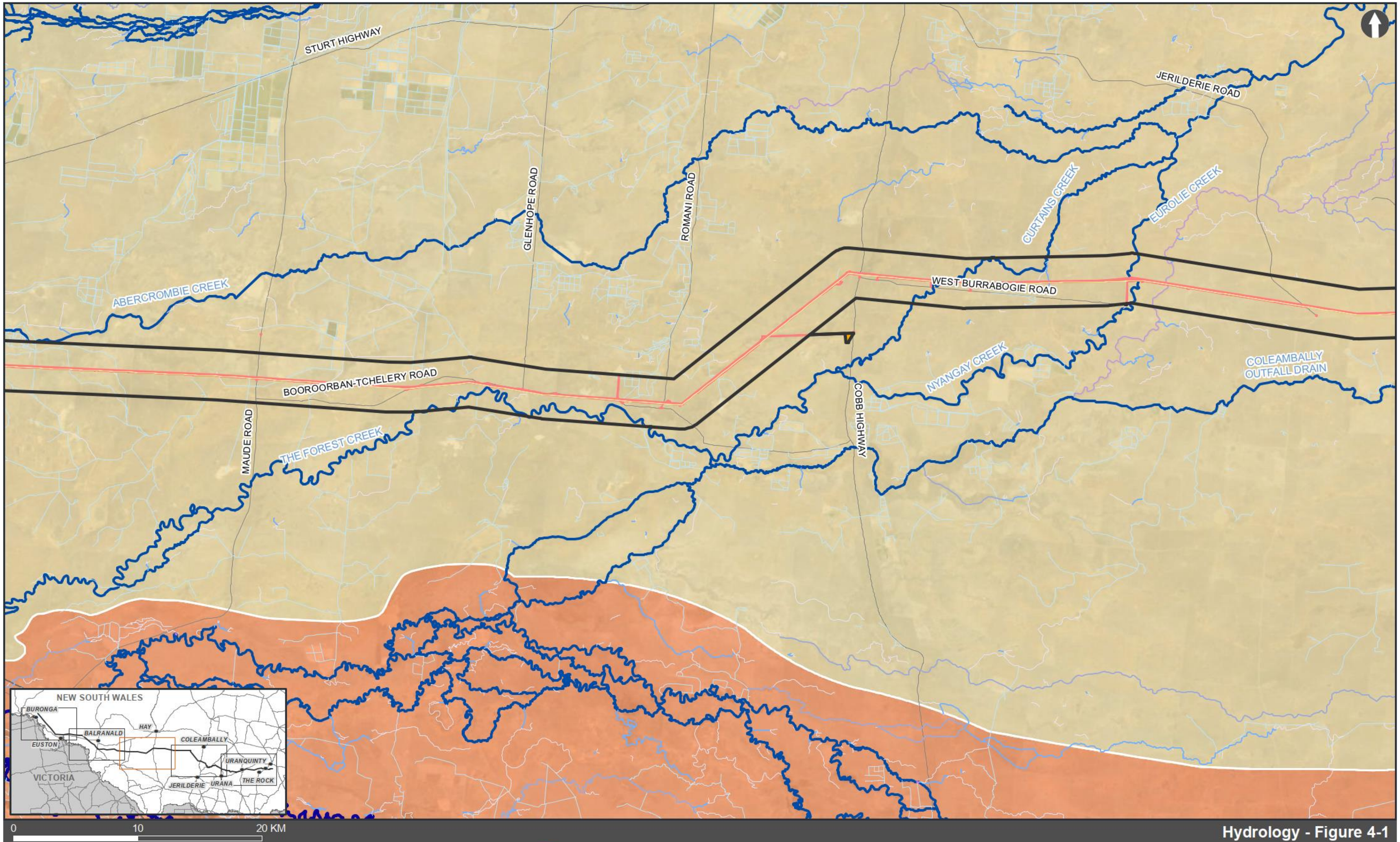

Hydrology - Figure 4-1

Project Components
- Construction Impact Area
- Main Construction Compounds and Accomodation Sites
- Water Fill Point
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Surface Water Study Area
- Built Up Areas
- Waterbody

Catchment Boundaries
- Murray River Basin
- Murrumbidgee River Basin

Strahler Stream Order
- Strahler Stream Order - 0
- Strahler Stream Order - 1
- Strahler Stream Order - 2
- Strahler Stream Order - 3
- Strahler Stream Order - 4
- Strahler Stream Order - 6
- Strahler Stream Order - 9
- Strahler Stream Order - 10

Waterways, Waterbodies and Catchments in the Study Area

Sheet 3 of 5

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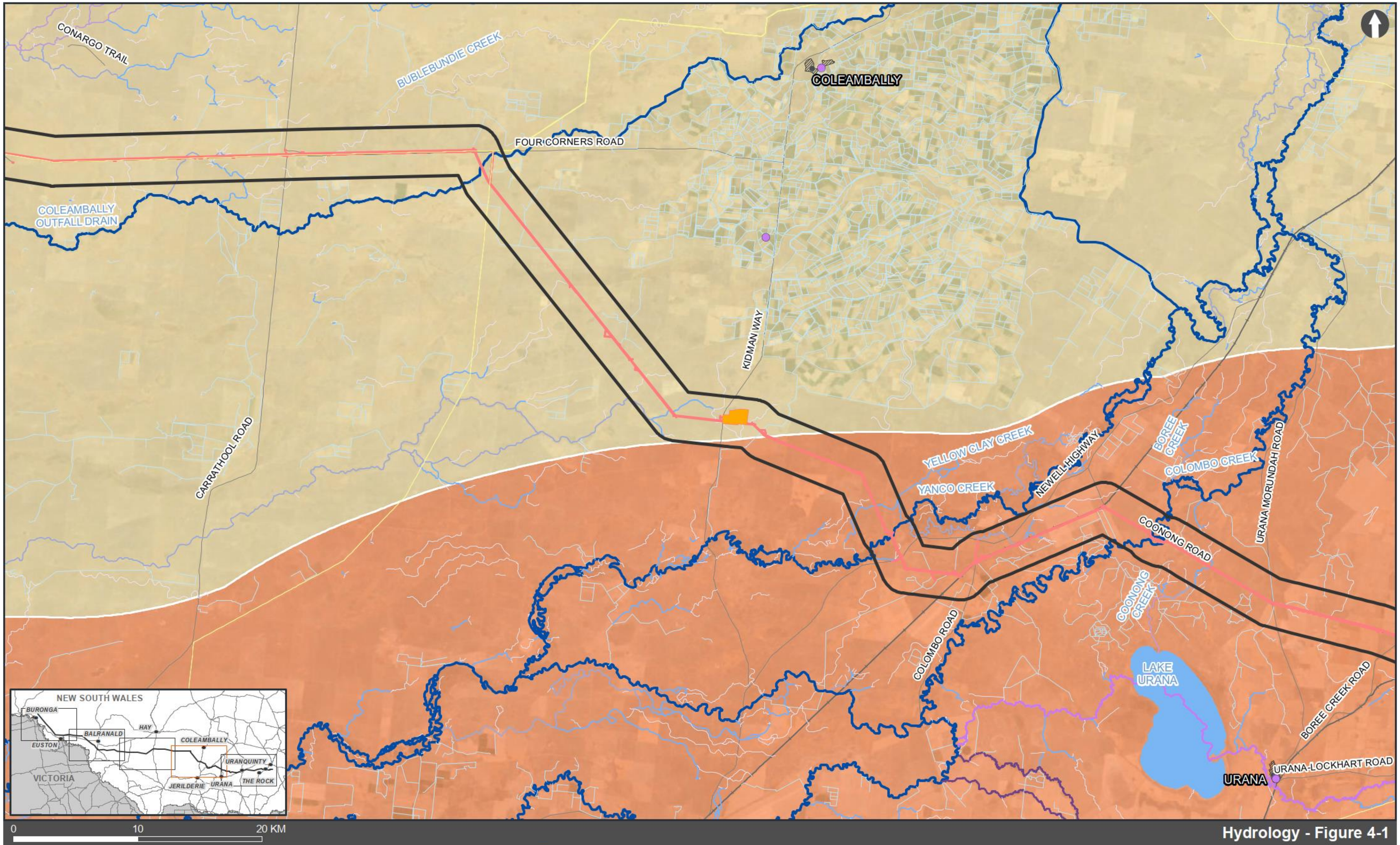
Source: NSWSS, ESRI, Transgrid, WSP



Hydrology - Figure 4-1

Project Components
- Construction Impact Area
- Main Construction Compounds and Accomodation
- Water Fill Point
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Surface Water Study Area
- Built Up Areas
- Waterbody

Catchment Boundaries
- Murray River Basin
- Murrumbidgee River Basin

Strahler Stream Order
- Strahler Stream Order - 0
- Strahler Stream Order - 1
- Strahler Stream Order - 2
- Strahler Stream Order - 3
- Strahler Stream Order - 4
- Strahler Stream Order - 6
- Strahler Stream Order - 7
- Strahler Stream Order - 9

Waterways, Waterbodies and Catchments in the Study Area

Sheet 4 of 5

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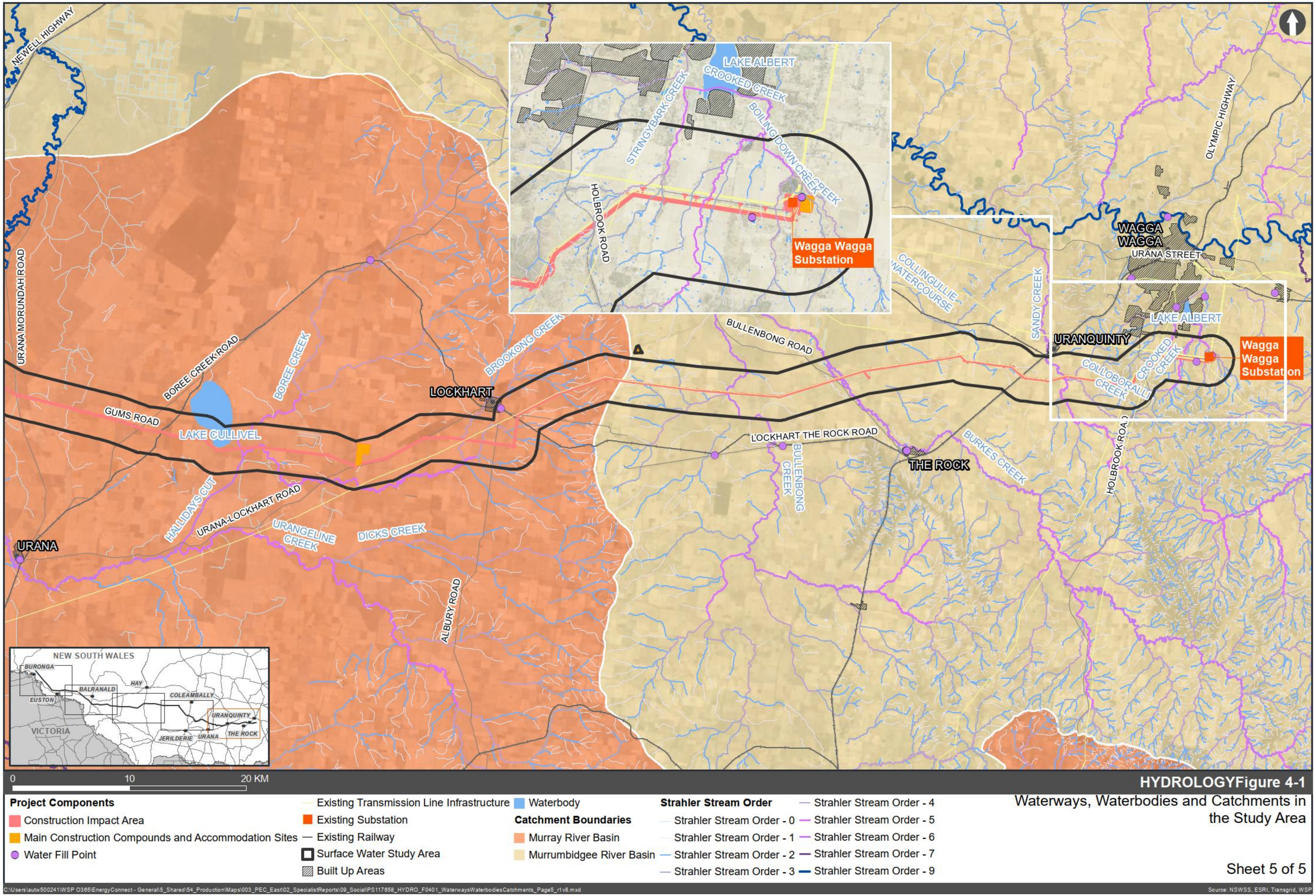


HYDROLOGY Figure 4-1

Waterways, Waterbodies and Catchments in the Study Area

Sheet 5 of 5

4.2 Climate and rainfall

The region has a semi-arid climate with hot summers and cool winters. The average temperature range is around 16°C to 33°C in summer and around 4°C to 15°C in winter. The average annual rainfall across the hydrology and flooding study area is variable, however generally average rainfall values are higher at the eastern end of the hydrology and flooding study area and lower at the western end.

The closest weather station to Buronga at the western end of the hydrology and flooding study area (Irymple, station number: 076015) records an average annual rainfall of 271 millimetres (1908–2020). Rainfall is typically fairly evenly spread across the year, with higher peak rainfall values from November to April. The Urana Post Office weather station (station number: 074110) near the eastern half of the hydrology and flooding study area records an annual average rainfall of 442.2 millimetres (1871–2020). The average monthly rainfall is slightly higher in May and June.

Near the eastern end of the hydrology and flooding study area, the average annual rainfall at Wagga Wagga Gurwood Street station (station number: 074127) is 528.1 millimetres from 2001–2020 and 568 millimetres from 1941–2020 at Wagga Wagga AMO station (station number: 072150).

4.2.1 Climate change

NSW and ACT Regional Climate Modelling (NARCliM) project uses global climate model outputs and downscales these to provide finer, higher resolution climate projections for a range of meteorological variables across 12 different regions in NSW and ACT. The NARCliM far west model predicts an increase of up to five percent in annual rainfall across the proposal area. However, the seasonal projections show a decrease in winter and spring rainfall but an increase in summer and autumn rainfall. Figure 4-2 and Figure 4-3 presents the NARCliM output for the Far West and Murray Murrumbidgee mean annual rainfall change and Figure 4-4 and Figure 4-5 presents the spring seasonal output for the Far West and Murray Murrumbidgee regions.

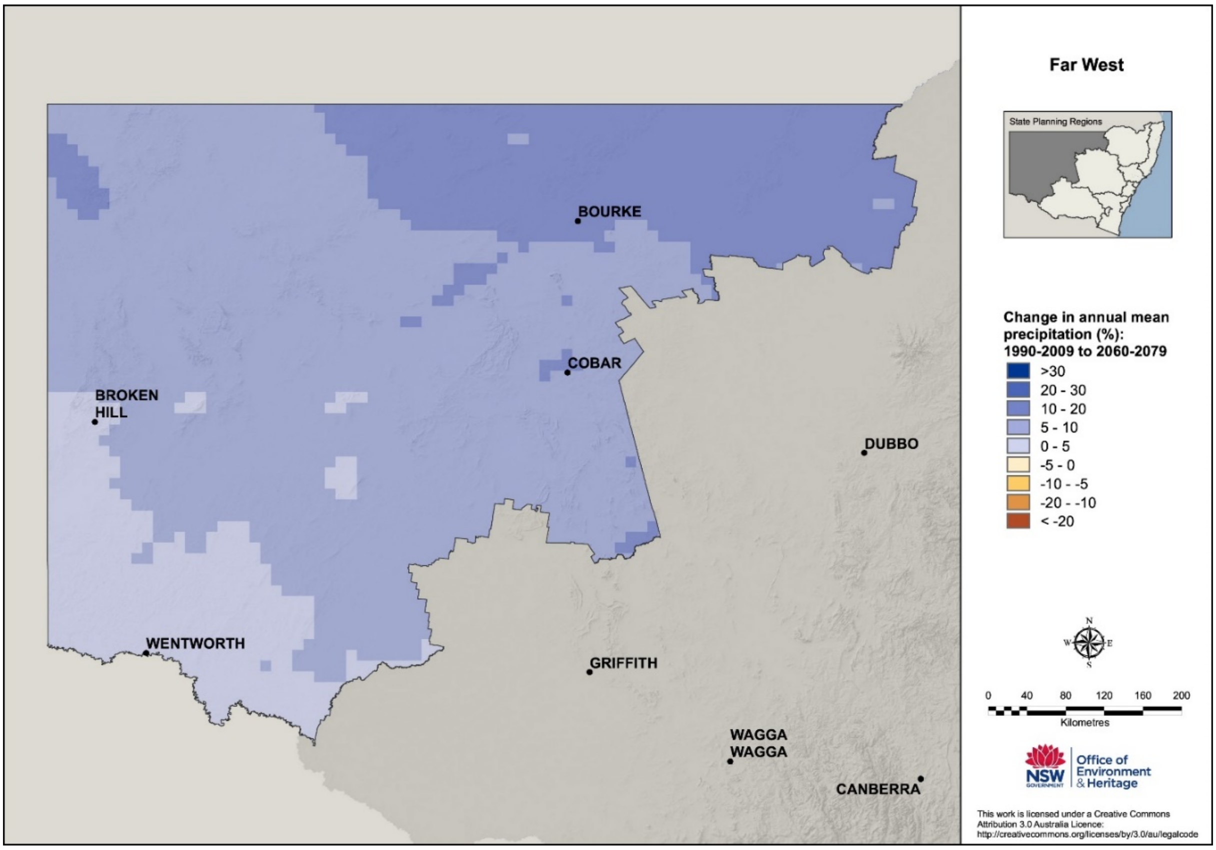


Figure 4-2 Far West change in Annual Mean rainfall (NSW OEH, 2014)

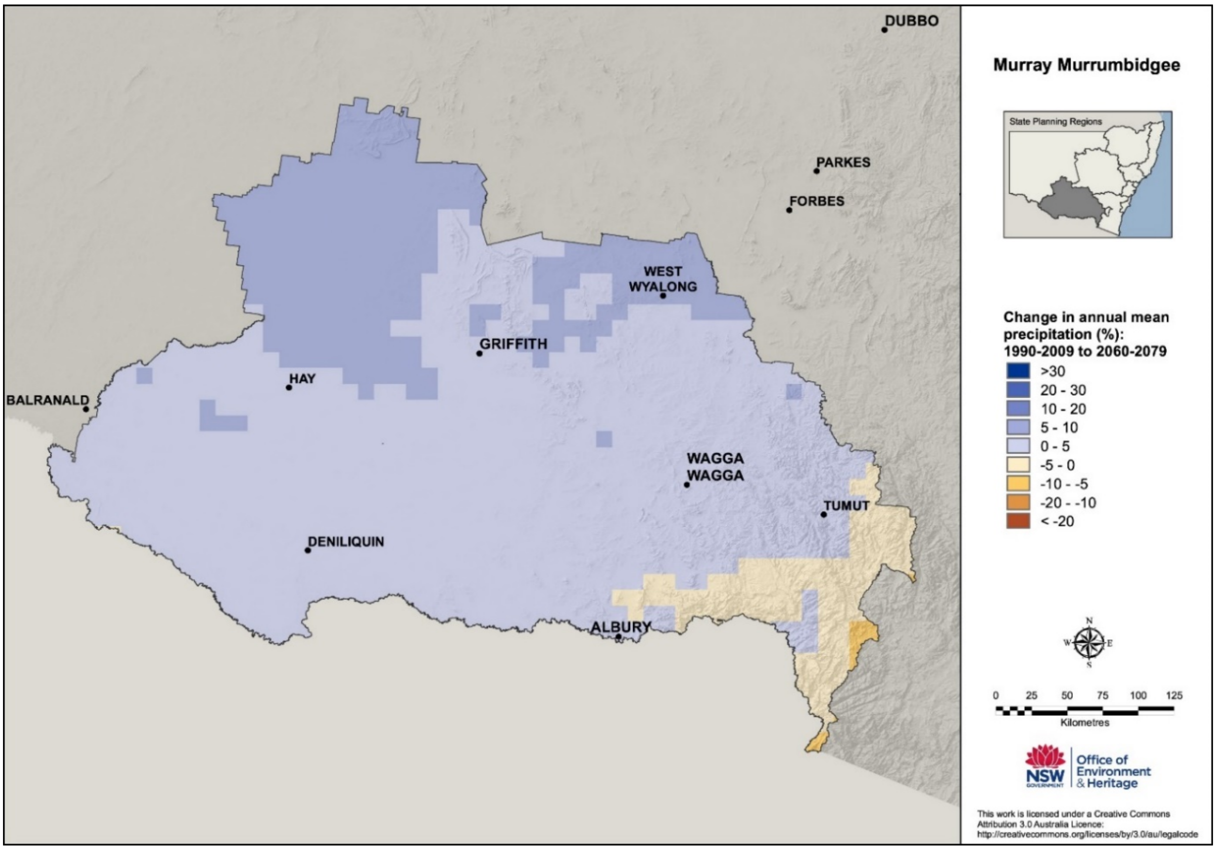


Figure 4-3 Murray Murrumbidgee change in Annual Mean rainfall (NSW OEH, 2014)

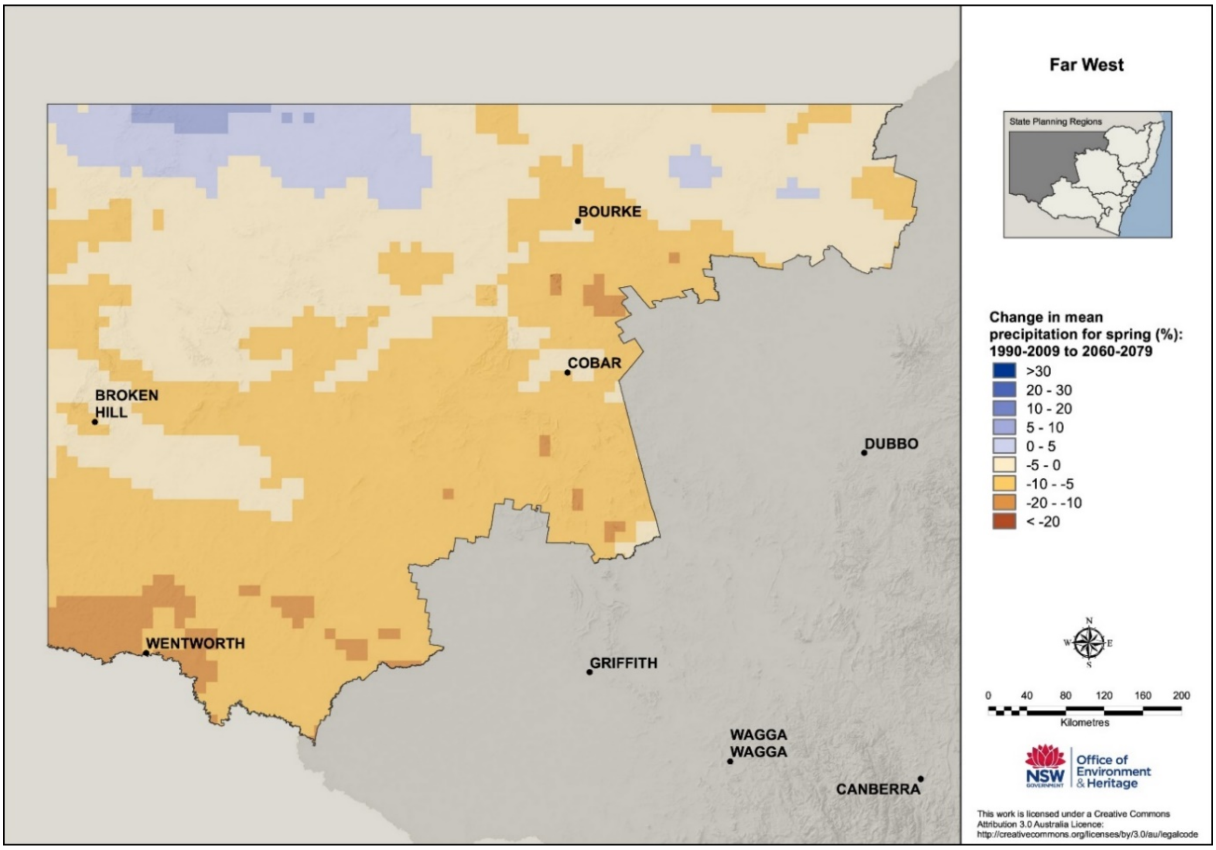


Figure 4-4 Far West change in mean spring rainfall (NSW OEH,2014)

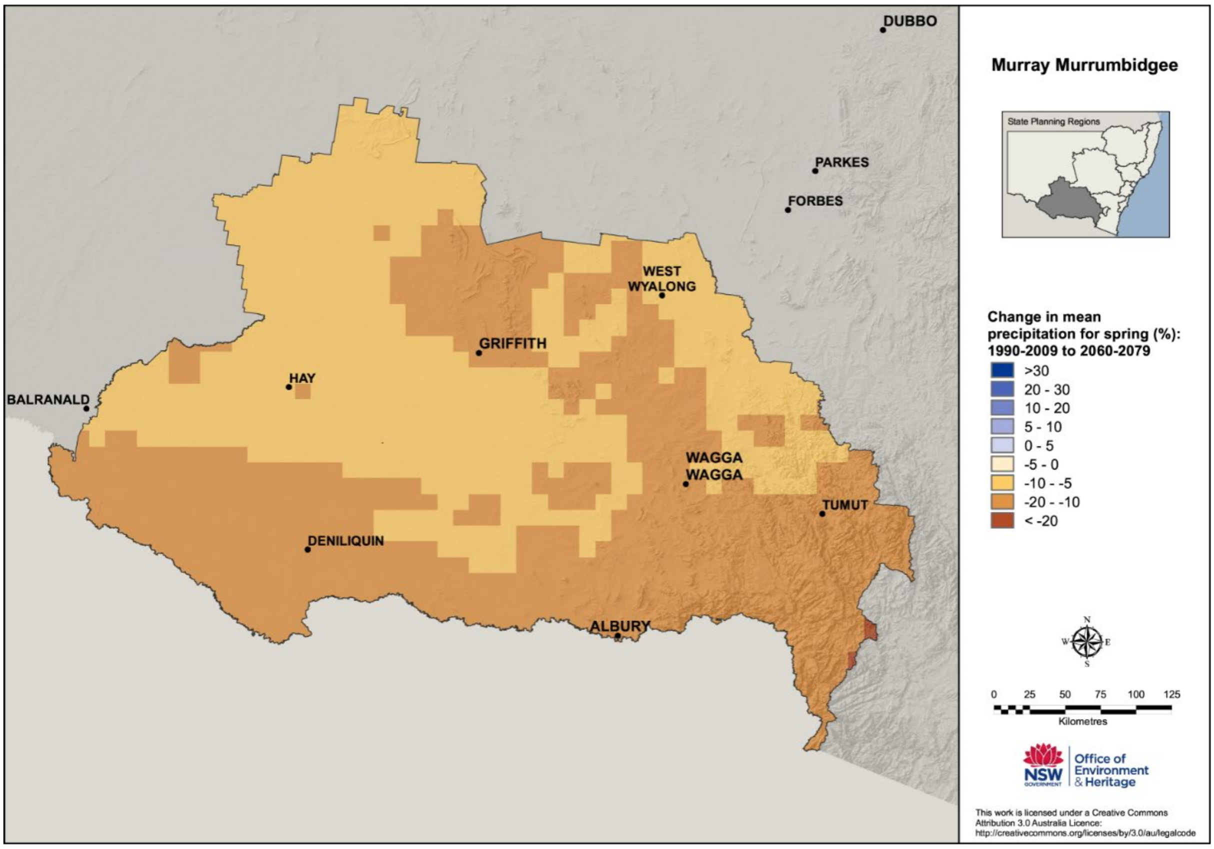
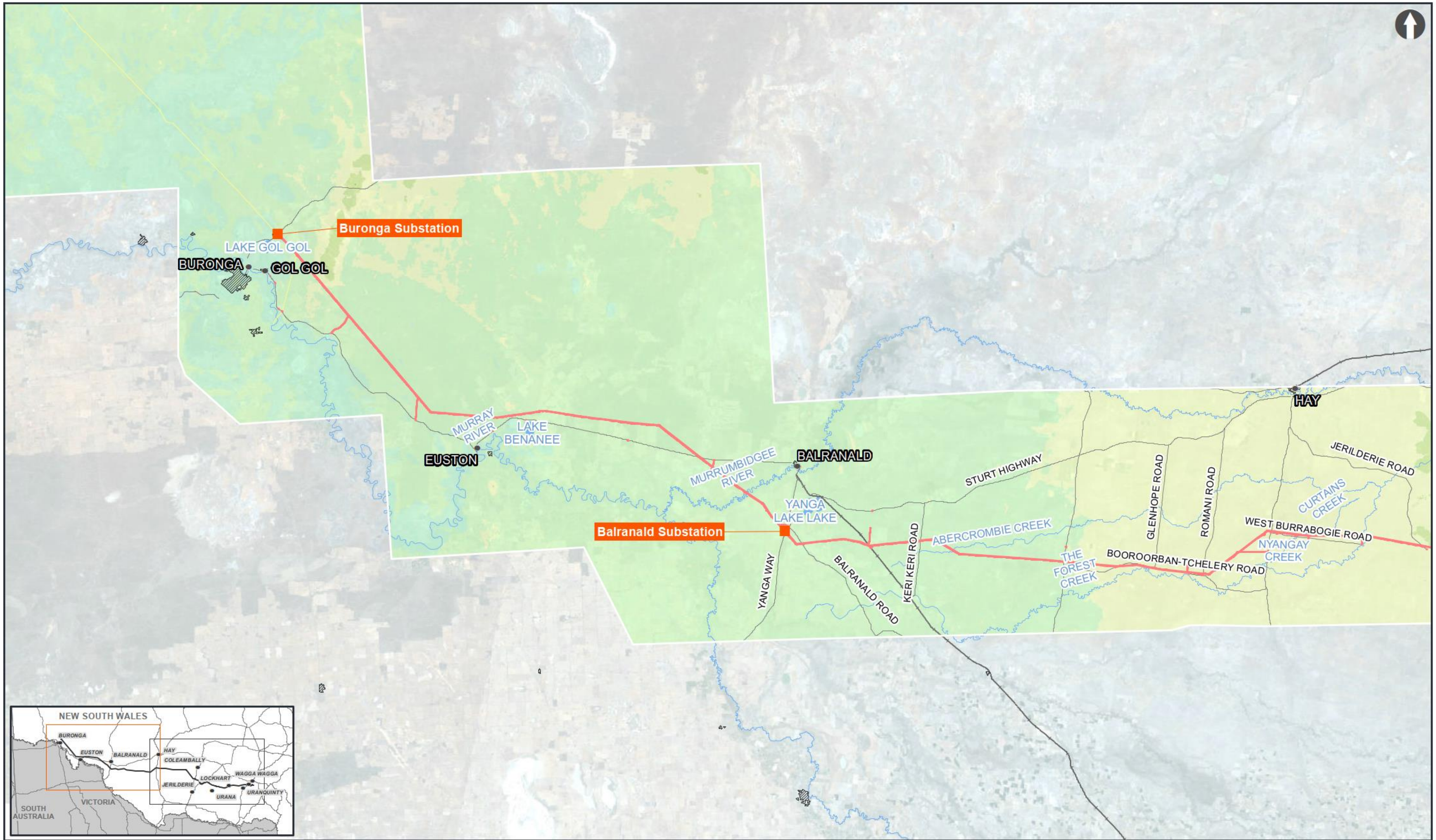


Figure 4-5 Murray Murrumbidgee change in mean spring rainfall (NSW OEH,2014)

The projected increase in mean annual rainfall will impact the overall water availability in the hydrology and flooding study area but higher projected temperatures will also mean higher rates of evaporation which will negate the projected increase. The projected higher temperatures are estimated to result in increased rainfall intensities. This will change the behaviour of a flood event such that peak flood levels will occur faster but it is not likely to have a significant impact on the duration of flood events across the hydrology and flooding study area because flooding is dominated by the upstream catchments. Refer to Section 4.4 for a description of flood behaviour.

4.3 Topography

The topography of the hydrology and flooding study area varies from the western end to the eastern end. At a macro level, the catchments slope from east to west with the eastern end of the hydrology and flooding study area at about 200 metres above sea level and the western end of the hydrology and flooding study area at about 40 metres above sea level at Mildura. While the terrain varies, it is generally flat to undulating plains country. Localised topographic highs of up to about 380 metres Australian Height Datum (AHD) occur about 10 kilometres west of the Wagga Wagga substation. The topography of the study area is shown on Figure 4-6.



0 10 20 KM

Hydrology - Figure 4-6

Topography

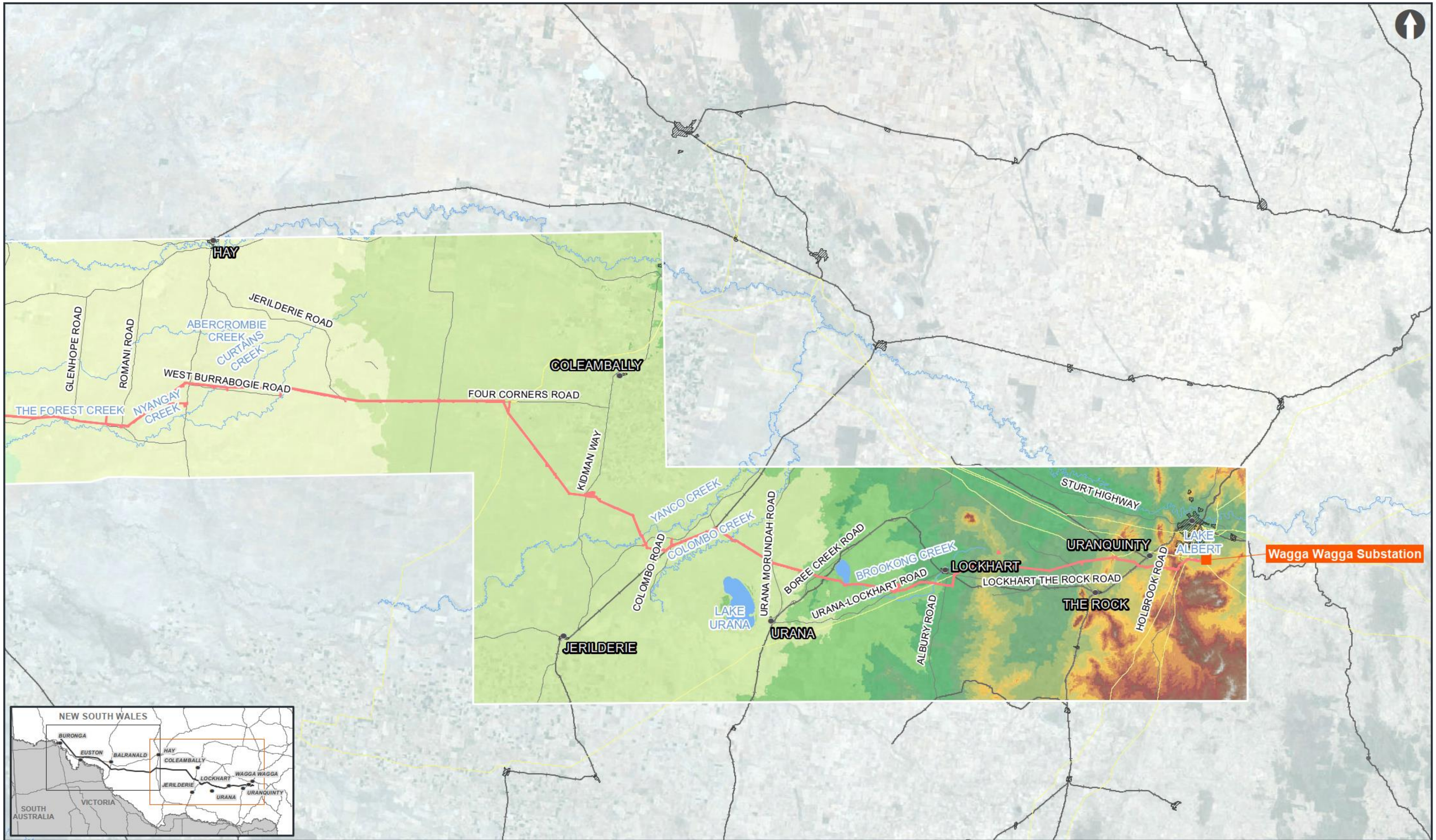
Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation Sites
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Built Up Areas
- Waterbody

Surface Elevation (10m intervals)

- 18 - 25
- 25 - 50
- 50 -75
- 75 - 100
- 100 - 125
- 125 - 150
- 150 - 175
- 175 - 200
- 200 - 225
- 225 - 250
- 250 - 275
- 275 - 300
- 300 - 325
- 325 - 350
- 350 - 375
- 375 - 400
- 400 - 425
- 425 - 450
- 450 - 475
- 475 - 500
- 500 - 525
- 525 - 550
- 550 - 575
- 575 - 60

Sheet 1 of 2



Hydrology - Figure 4-6
Topography

Project Components
- Construction Impact Area
- Main Construction Compounds and Accommodation Sites
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Built Up Areas
- Waterbody

Surface Elevation (10m intervals)
- 18 - 25
- 25 - 50
- 50 -75
- 75 - 100
- 100 - 125
- 125 - 150
- 150 - 175
- 175 - 200
- 200 - 225
- 225 - 250
- 250 - 275
- 275 - 300
- 300 - 325
- 325 - 350
- 350 - 375
- 375 - 400
- 400 - 425
- 425 - 450
- 450 - 475
- 475 - 500
- 500 - 525
- 525 - 550
- 550 - 575
- 575 - 60

Sheet 2 of 2

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Source: NSWSS, ESRI, Transgrid, WSP

4.4 Flooding conditions

The following sections provide on existing available flooding information for the hydrology and flooding study area.

4.4.1 Historic flood data

The *Wagga Wagga Flood Plan* (SES, 2006) describes flooding in the Wagga Wagga area. The plan notes that there are storage dams located in the upper Murrumbidgee valley that can affect the severity of flooding on the Murrumbidgee River as these dams can reduce the peak flood discharge, resulting in lower peak flood heights but longer flood durations. This may be done by deliberately storing the flood peak for later release, or by pre-releasing water to create extra space in the dam ahead of an approaching flood. These actions, however, do not mitigate floods and their effectiveness is dependent upon dam levels. The report also notes that there are numerous small creeks in the council area that tend to rise and fall quickly and there are no warning systems in place with any creeks in the council area.

The plan also records a history of flooding in the Wagga Wagga Council. The Murrumbidgee River near Wagga Wagga has flooded most recently in 2012 reaching a peak of 10.56 metres.

The *Lockhart Floodplain Risk Management Study* (WMA Water, 2014) showed that much of the town of Lockhart would become inundated during a 1% Annual Exceedance Probability (AEP) flood event due to flooding along Brookong Creek this includes along Lockhart – The Rock Road which is crossed by the proposal. The plan notes that flooding can occur at any time of year but is most likely to occur during winter and spring as a result of frontal systems crossing the area from west to east. Some flash flooding may also occur in summer due to high-intensity thunderstorms that may occur.

Landowners near Lake Cullivel have provided photographic evidence of a flood event (date unknown) to show the extent of inundation at Lake Cullivel. Figure 4-7 includes the available historic flood photograph and a snapshot of the proposal alignment. The photograph shows that part of the alignment would cross flood prone land.

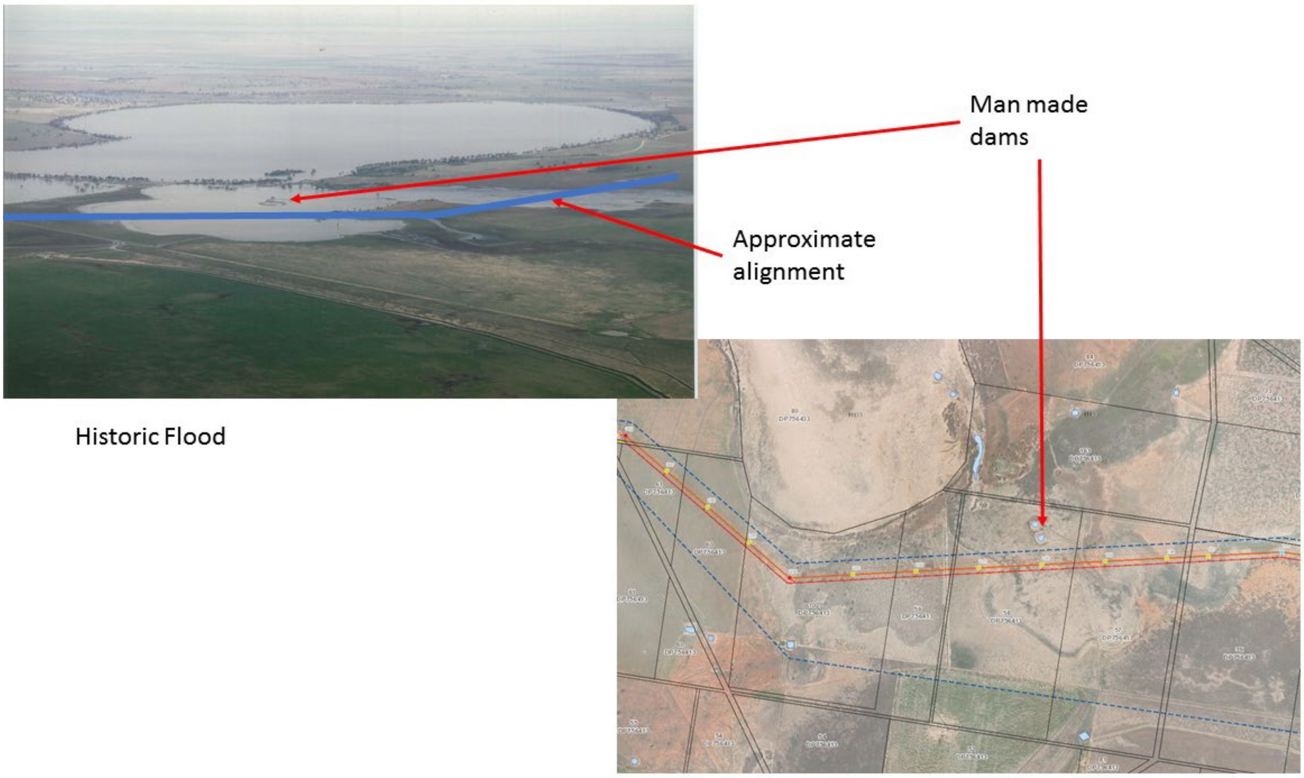


Figure 4-7 Historic flood event at Lake Cullivel

4.4.2 Flood impact assessment

A high level flood risk assessment has been completed by Beca (Beca, 2020) to understand the potential extent of flooding in the vicinity of the proposal. The assessment estimated the flood depth and extent for the 1% AEP event as shown in Figure 4-8. Based on the risk assessment, there are large floodplains around Box Creek, the Murrumbidgee River, Condoulpe Creek, Yellow Clay Creek, Coonong Creek, Bullenbong Creek and dispersed flooding at the very eastern end of the proposal around Sawpit Gully, Crooked Creek and Boiling Down Creek. Depths in the main river channels are estimated to be up to six metres and up to two metres across the floodplains for the hydrology and flooding study area (Beca 2020).

The flood risk assessment indicates that peak velocities where the proposal crosses the river in the main channel of Abercrombie Creek, Curtains Creek, Nyangay Creek, Eurolie Creek and Bublebundie Creek are less than 0.5 metres per second. Peak velocities in Box Creek, Yanco Creek, Colombo Creek and Coonong Creek are less than one metre per second and peak flood velocities in all other watercourses are greater than one metre per second up to three metres per second.

4.4.3 Flood affected features

The Beca flood risk assessment has been used to understand the flood affectation of features such as buildings and infrastructure across the hydrology and flooding study area. It is noted that this affectation is limited to the information available and does not supersede any local information sourced from local studies or supplied by local councils.

Flood affected features are largely near existing waterways. The hydrology and flooding study area near Talia Creek, Murrumbidgee River, Condoulpe Creek, The Forest Creek, Yellow Clay Creek, Colombo Creek, Yanco Creek, Hallidays Cut, Brookong Creek, Bullenbong Creek, Sandy Creek, Sawpit Gully and Crooked Creek is predicted to have surrounding floodplains. These predicated floodplains contain numerous flood affected receivers including industrial and community facilities and residential dwellings. Additionally, there are floodplain areas in the assessment area between Colombo Creek and Hallidays Cut to the north of Lake Urana which include a number of flood affected receivers. No floor levels for these structures is available to determine the actual flood affectation of these structures.

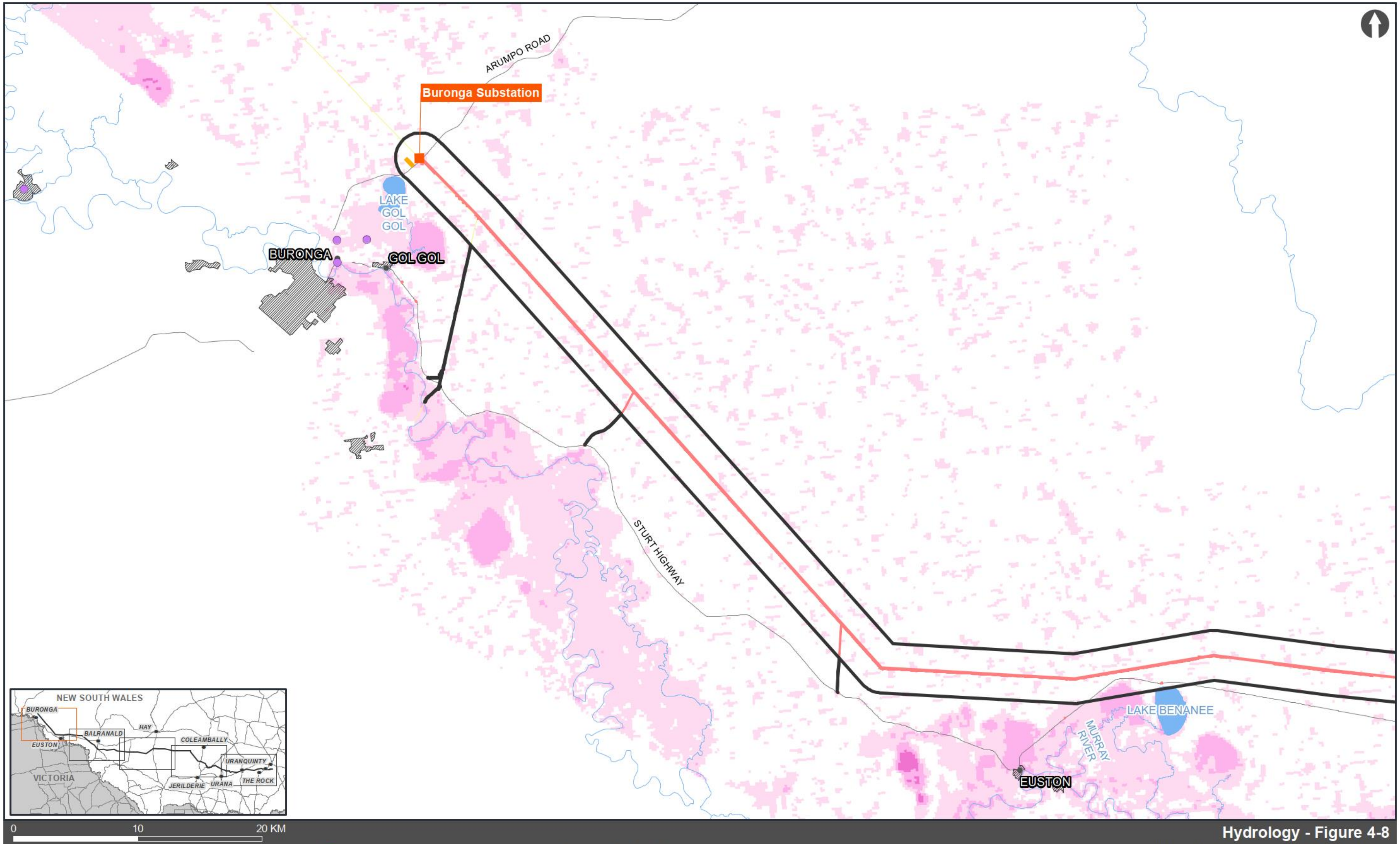
Flood affected roads would include the Sturt Highway near the Box Creek and Murrumbidgee River crossing, Balranald Road near Condoulpe Creek, Booroorban-Tchelery Road near the Forest Creek, West Burrabogie Road near Curtains Creek, the Newell Highway near Yanco Creek, Federation Highway and a number of unnamed access roads, near Coonong Creek and Lake Urana, County-Boundary Road, Lockhart Road, Bullenbong - Rock Road, Lockhart -The Rock Road and Boyds Road near Bullenbong Creek and Burkes Creek. From the crossing of the proposal at Sandy Creek eastward, most road traversing the hydrology and flooding study area would receive some level of flood impact due to the network of watercourses in the area.

Flood related infrastructure for floodplain harvesting such as flood levees or flood control banks are identified within the floodplains of the Murrumbidgee and are described in the *Wagga Wagga Flood Plan* (SES, 2006). The intent of floodplain harvesting infrastructure is to opportunistically capture floodplain flows and store the floodwaters for later use.

4.4.4 Flood emergency management arrangements

The proposal is located across the local government areas of Wentworth, Balranald, Edward River, Hay, Murrumbidgee, Federation, Lockhart and Wagga Wagga. The NSW SES provides flood emergency sub plans for each of these local government areas. These plans set out roles and responsibilities for preparedness, response and recovery to flood events. All flood emergency plans rely on the Bureau of Meteorology (BoM) for notification of a flood event in the Murray River Basin and to provide severe weather warnings when flash flooding is likely to occur.

The *Lockhart Shire Flood Emergency Sub Plan* (NSW SES, 2013) is relevant for the section of the proposal near the town of Lockhart and the Brookong Creek. The plan notes that while flood weather warnings are issued by the BoM for the Murrumbidgee River Basin, no BoM flood warnings are issued for specific streams within the Lockhart catchment. There are no stream gauges on the Brookong Creek upstream of Lockhart and flood warnings for Lockhart are limited.



Hydrology - Figure 4-8

Flooding Depth in the Study Area

Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation Sites
- Water Fill Point
- Waterbody
- Existing Substation
- Existing Transmission Line Infrastructure
- Existing Railway
- Surface Water Study Area
- Built Up Areas

Flooding Depth (m)

- 1m - 5m
- 5m - 10m
- 10m - 20m

Sheet 1 of 5

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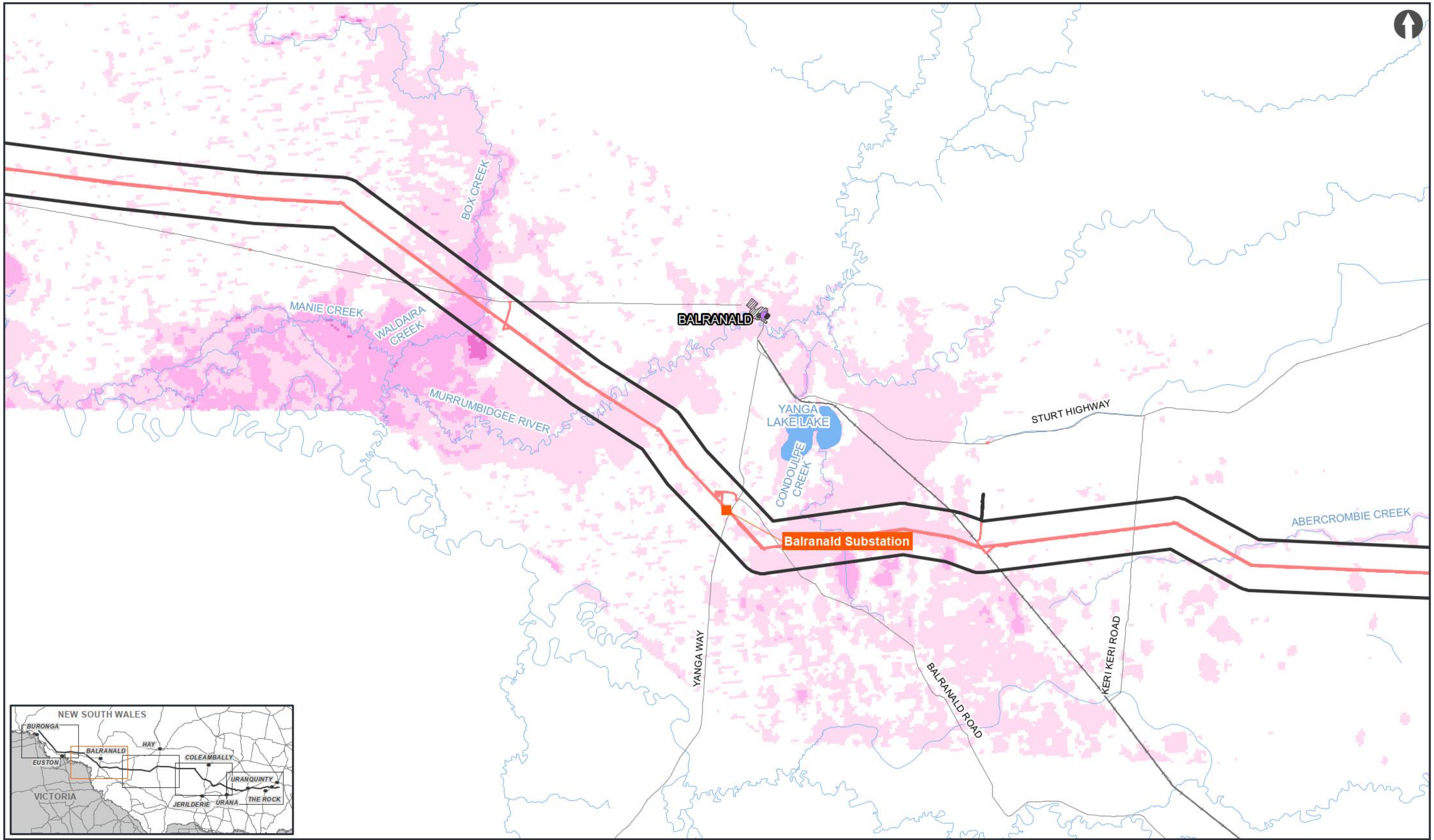
Source: NSWSS, ESRI, Transgrid, WSP



Hydrology - Figure 4-8

Flooding Depth in the Study Area

Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation Sites
- Water Fill Point
- Waterbody
- Existing Substation
- Existing Transmission Line Infrastructure
- Existing Railway
- Surface Water Study Area
- Built Up Areas

Flooding Depth (m)

- 1m - 5m
- 5m - 10m
- 10m - 20m

Sheet 2 of 5

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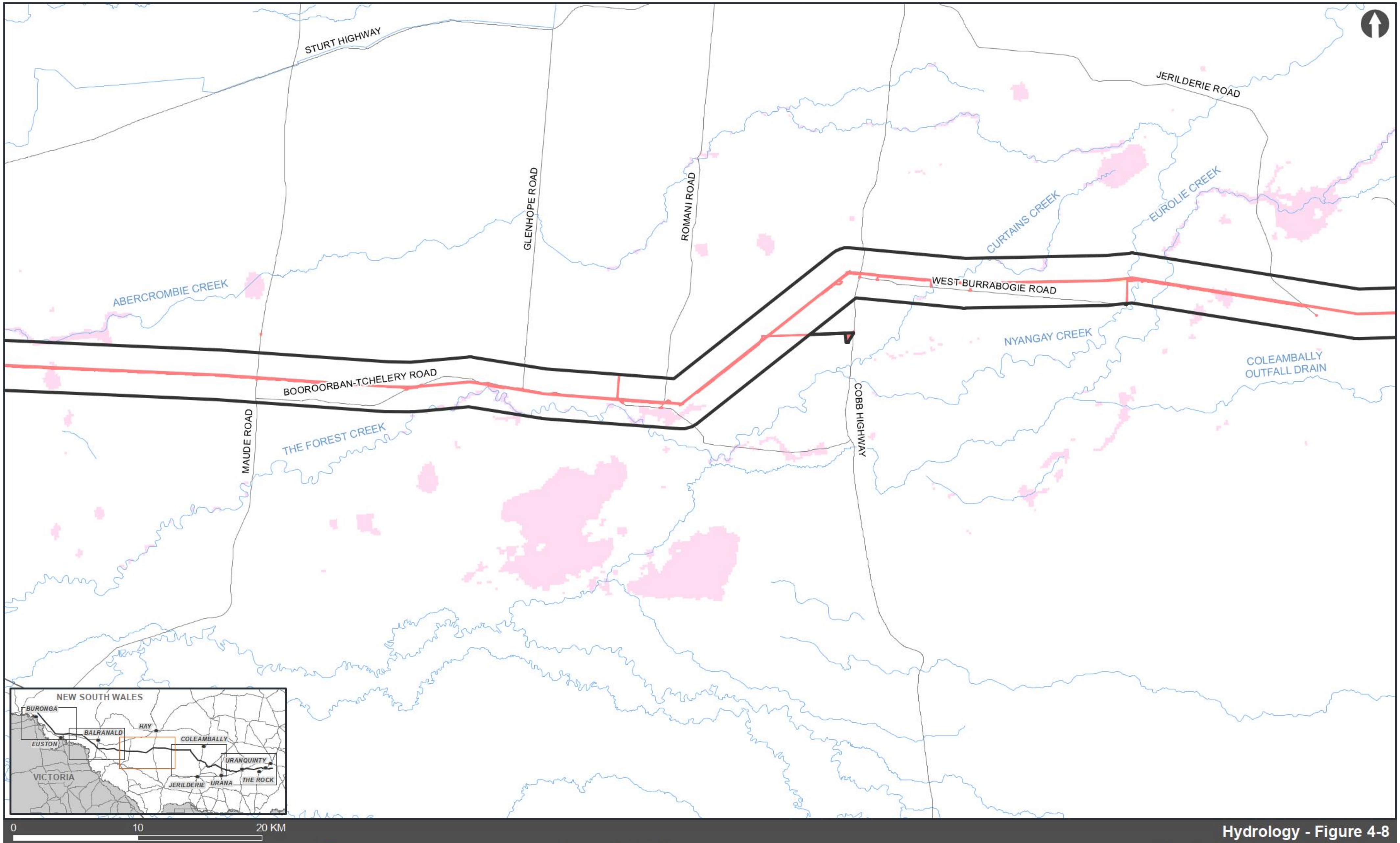
Source: NSWSS, ESRI, Transgrid, WSP



Hydrology - Figure 4-8

Flooding Depth in the Study Area

Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation Sites
- Water Fill Point
- Existing Substation
- Existing Transmission Line Infrastructure
- Existing Railway
- Surface Water Study Area
- Built Up Areas

Flooding Depth (m)

- 1m - 5m

Sheet 3 of 5

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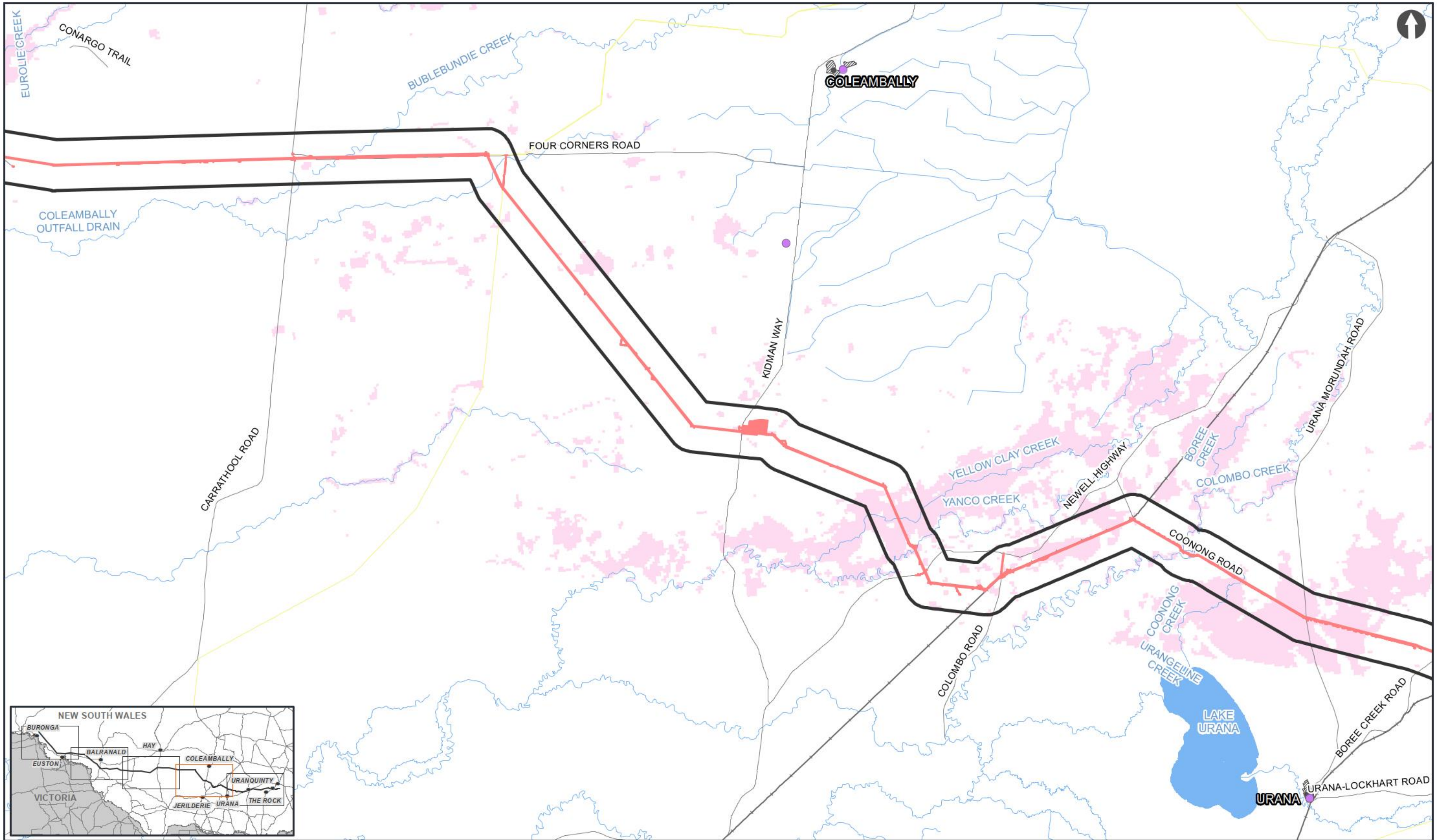
Source: NSWSS, ESRI, Transgrid, WSP



Hydrology - Figure 4-8

Flooding Depth in the Study Area

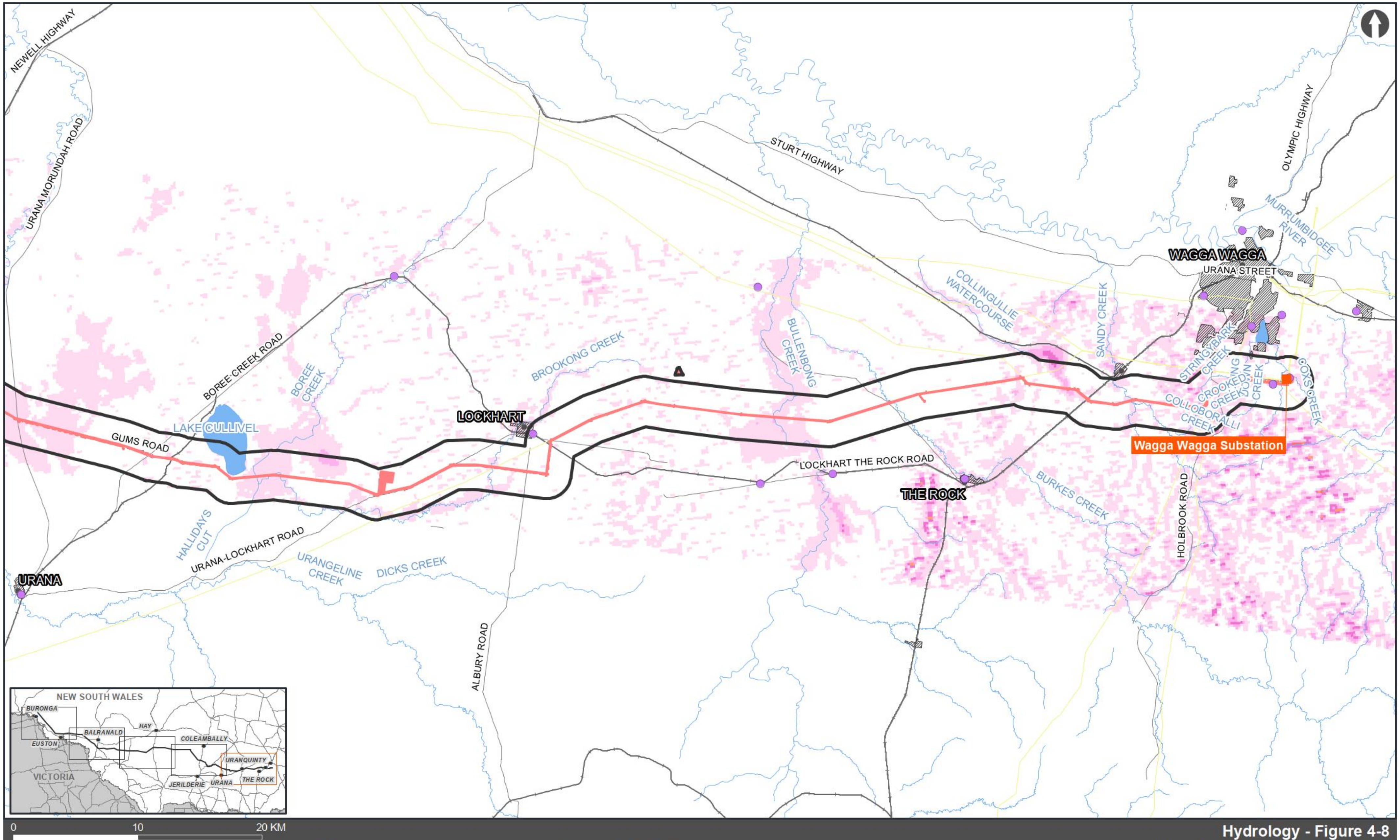
Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation Sites
- Water Fill Point
- Waterbody
- Existing Substation
- Existing Transmission Line Infrastructure
- Existing Railway
- Surface Water Study Area
- Built Up Areas

Flooding Depth (m)

- 1m - 5m

Sheet 4 of 5



Hydrology - Figure 4-8

Flooding Depth in the Study Area

Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation Sites
- Water Fill Point
- Waterbody
- Existing Substation
- Existing Transmission Line Infrastructure
- Existing Railway
- Surface Water Study Area
- Built Up Areas

Flooding Depth (m)

- 1m - 5m
- 5m - 10m
- 10m - 20m
- 20m - 30m
- >30m

Sheet 5 of 5

4.5 Water supply and water resources

Existing water supplies to the urban area around Wagga Wagga are from the Murrumbidgee River and groundwater bores (Riverina Water, 2020). Rainwater collected from roofs is another source of domestic water supply for the urban area. The CSIRO reports that 53 percent of available surface water (including transfers from the Snowy Mountains Hydro-electric Scheme) is extracted for use, which is very high compared with other catchments in the Basin. Groundwater extraction is 17 percent of available resources, mainly in the mid to lower catchment (MDBA, 2021).

Existing water supplies to the urban area around Mildura are managed by Lower Murray Water and are largely taken from the Murray River and Lake Hume.

The Water Sharing Plan for the New South Wales Murrumbidgee Regulated Rivers Water Sources 2016, Murrumbidgee Unregulated Rivers Water Sources 2012, Murray and Lower Darling Regulated Rivers Water Sources 2016 and Murray and Lower Darling Unregulated Rivers Water Sources 2011 covers the surface water in the water sources in the hydrology and flooding study area. The plans include the objectives for the water source which include:

- environmental
- economic
- Aboriginal cultural
- social and cultural.

To achieve these objectives, the water allocations are to be adjusted when any reduction in the availability of water is detected due to an increase in extraction above the long-term average annual extraction limit or the long term average sustainable diversion limit (NSW Department of Planning, Industry and Environment, 2020).

Environmental water is a large component of the water allocation. The Environmental Water Register maintained by the Department of Industry provides a record of licenced environmental water, as well as other water intended to be used for environmental purposes. The environmental water licences active under the water sharing plans relevant to the hydrology and flooding study area are as follows:

- Murrumbidgee Regulated River Water Sources 2016 – 47 licences
- Murrumbidgee Unregulated River Water Sources 2012 – 6 licences.

As of 27 July 2021, there are no active environmental water licences under the Murray and Lower Darling Regulated Rivers Water Sources 2016 and Murray and Lower Darling Unregulated Rivers Water Sources 2011.

4.6 Land uses

Land use in the Murrumbidgee Valley is diverse, reflecting the differences in geography and climate across the region. Dryland grazing and cereal-based cropping account for more than 75 percent of land use and five percent is irrigated. Commercial forestry occupies about three percent of the catchment, mainly in the east. Tourism is also an important industry for the region.

Land use data from the NSW Government (NW, 2013) shows the land uses are predominantly cropping and grazing on both native and modified pastures. There are some areas of irrigated forestry and horticulture dispersed across the hydrology and flooding study area and some small areas of managed resource protection and intensive farming near the Wagga Wagga end of the hydrology and flooding study area. West of the Balranald substation, the proposal passes through the Yanga State Conservation Area. Figure 4-9 provides overview of land uses.

4.7 Soils and geology

The soils along the hydrology and flooding study area are expected to be generally comprised of calcarosols according to Australian Soil Classification (CSIRO, 2016) red dune fields, with some sand and vertisols found along the main watercourses alluvial plains in proximity to the Murrumbidgee and Darling, Rivers.

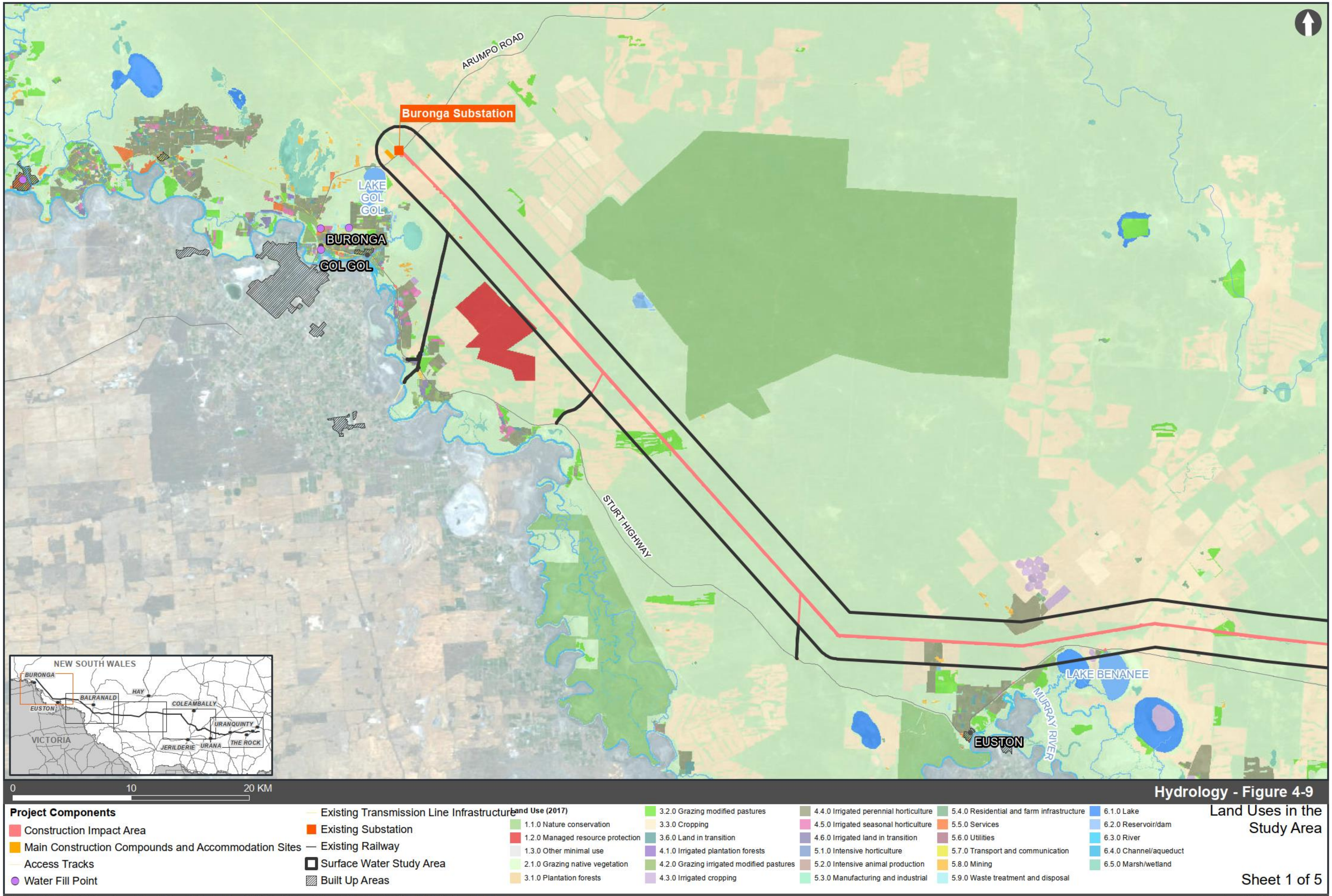
The soils along the hydrology and flooding study area are expected to be generally comprised of red dune fields, with some sand and alluvial plains in proximity to the Murrumbidgee and Darling Rivers. Published soil mapping along the alignment indicates that the regional geology and soils are expected to be predominantly transported Quaternary-aged sediments deposited in alluvial flood plains, and dune. The predominant soil types are typically sand and clay or a mixture of the two.

4.7.1 Soil salinity

Most of the hydrology and flooding study area is classified as having low salinity potential. Areas classified as having high salinity potential are not within the vicinity of the hydrology and flooding study area.

4.7.2 Acid sulfate soils

Acid sulfate soils and potential acid sulfate soils are naturally occurring soils containing iron sulphides. On exposure to air, iron sulphides oxidise and create sulfuric acid. This increase in acidity can result in the mobilisation of aluminium, iron and manganese from the soils. The CSIRO Australian Soil Resource Information System indicates that there is an extremely low to low probability of acid sulfate soils within most of the hydrology and flooding study area. The exception to this is near watercourses and lakes along the hydrology and flooding study area. Figure 4-10 shows the acid sulfate soil risk classifications for land within and in the vicinity of the hydrology and flooding study area.



Hydrology - Figure 4-9

Land Uses in the Study Area

Sheet 1 of 5

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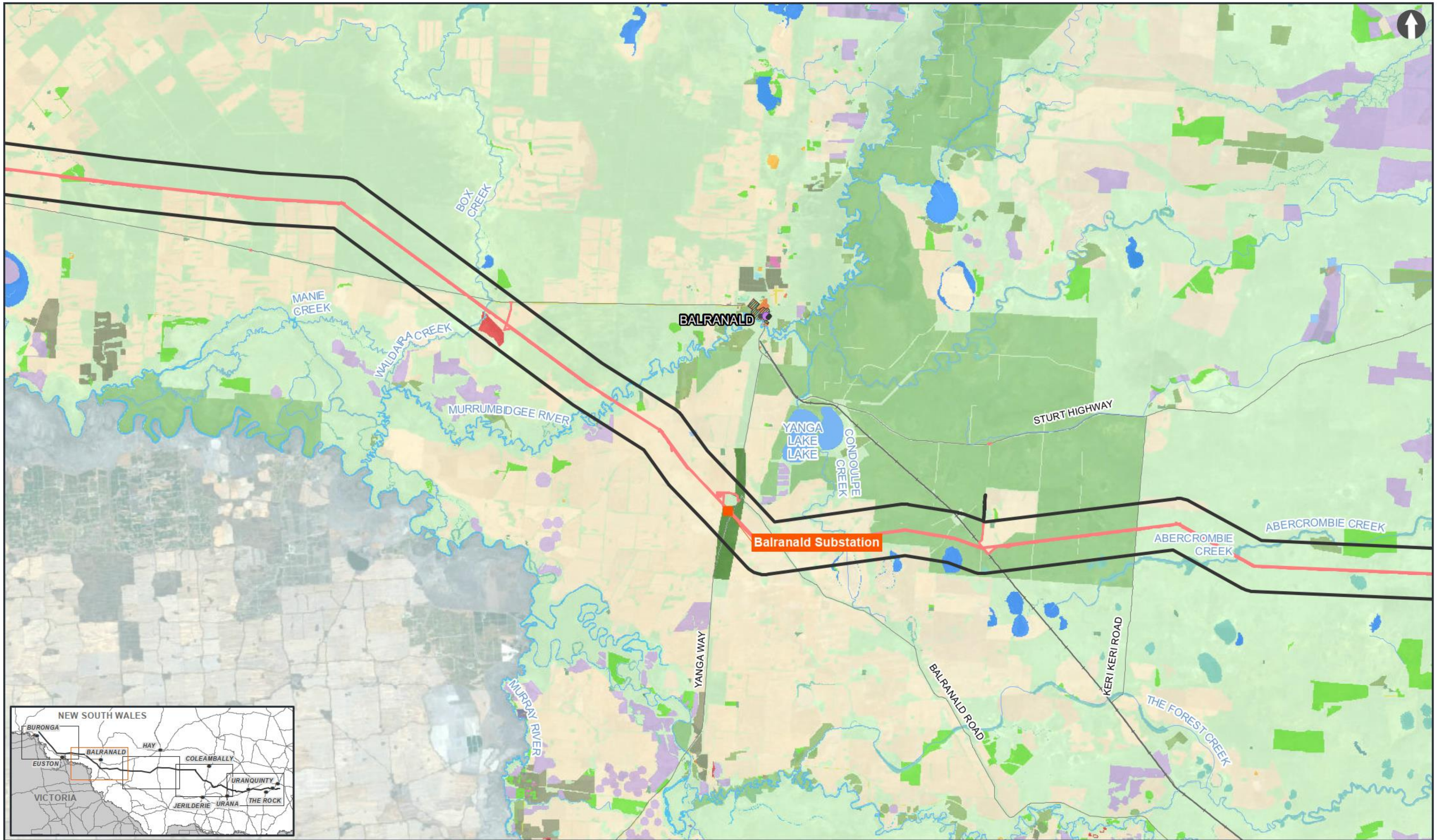
Source: NSWSS, ESRI, Transgrid, WSP



Hydrology - Figure 4-9

Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation Sites
- Access Tracks
- Water Fill Point
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Surface Water Study Area
- Built Up Areas

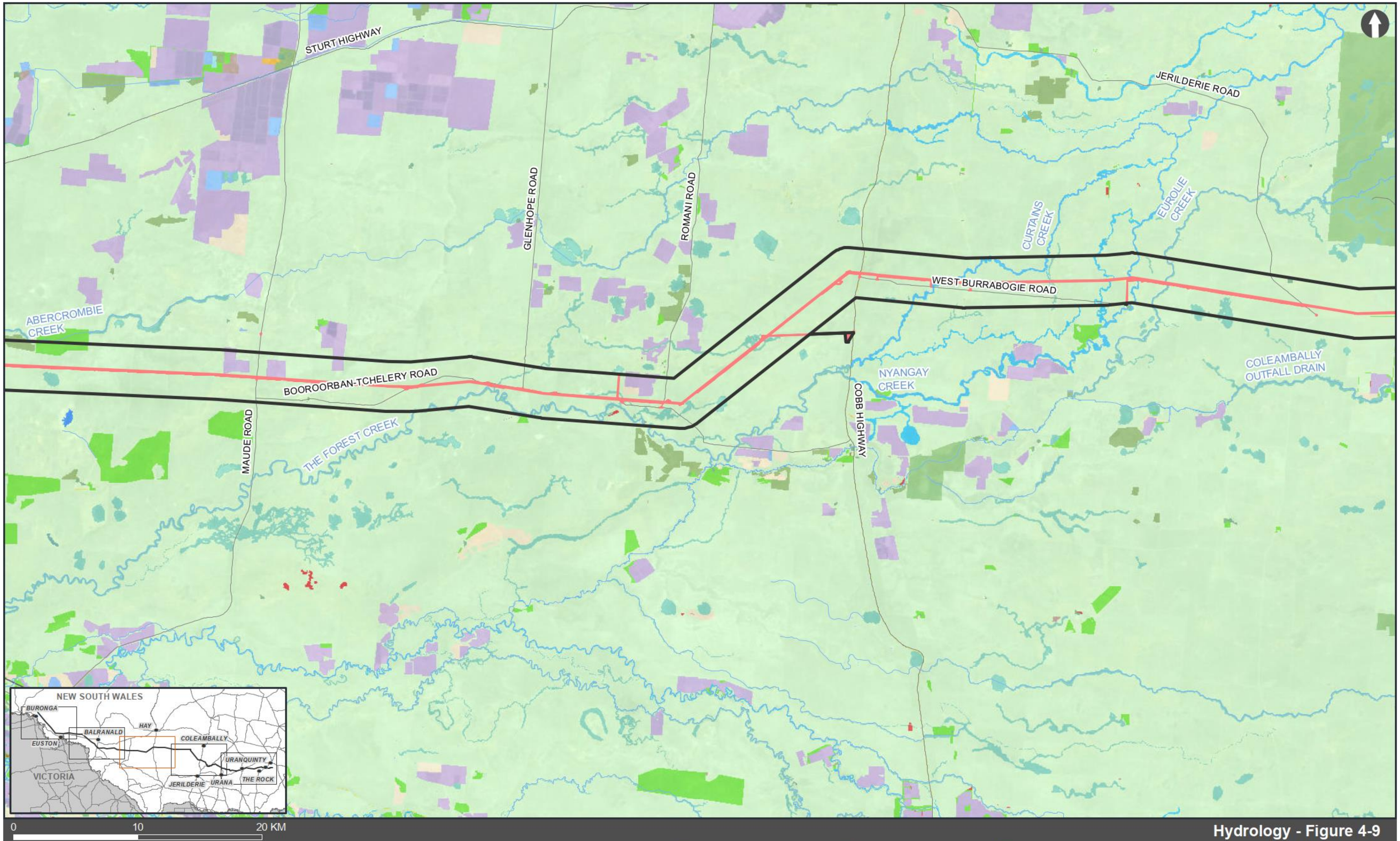
Land Use (2017)

- 1.1.0 Nature conservation
- 1.2.0 Managed resource protection
- 2.1.0 Grazing native vegetation
- 2.2.0 Production native forestry
- 3.1.0 Plantation forests
- 3.2.0 Grazing modified pastures
- 3.3.0 Cropping
- 3.4.0 Perennial horticulture
- 3.6.0 Land in transition
- 4.2.0 Grazing irrigated modified pastures
- 4.3.0 Irrigated cropping
- 4.4.0 Irrigated perennial horticulture
- 4.5.0 Irrigated seasonal horticulture
- 4.6.0 Irrigated land in transition
- 5.2.0 Intensive animal production
- 5.3.0 Manufacturing and industrial
- 5.4.0 Residential and farm infrastructure
- 5.5.0 Services
- 5.6.0 Utilities
- 5.7.0 Transport and communication
- 5.8.0 Mining
- 5.9.0 Waste treatment and disposal
- 6.1.0 Lake
- 6.2.0 Reservoir/dam
- 6.3.0 River
- 6.4.0 Channel/aqueduct
- 6.5.0 Marsh/wetland

Land Uses in the Study Area

Sheet 2 of 5

Source: NSWSS, ESRI, Transgrid, WSP



Hydrology - Figure 4-9

Land Uses in the Study Area

Sheet 3 of 5

Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation Sites
- Access Tracks
- Water Fill Point
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- Existing Railway
- Surface Water Study Area
- Built Up Areas

Land Use (2017)

- 1.1.0 Nature conservation
- 1.2.0 Managed resource protection
- 1.3.0 Other minimal use
- 2.1.0 Grazing native vegetation
- 3.2.0 Grazing modified pastures
- 3.3.0 Cropping
- 3.6.0 Land in transition
- 4.2.0 Grazing irrigated modified pastures
- 4.3.0 Irrigated cropping
- 5.2.0 Intensive animal production
- 5.3.0 Manufacturing and industrial
- 5.4.0 Residential and farm infrastructure
- 5.5.0 Services
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- 6.3.0 River
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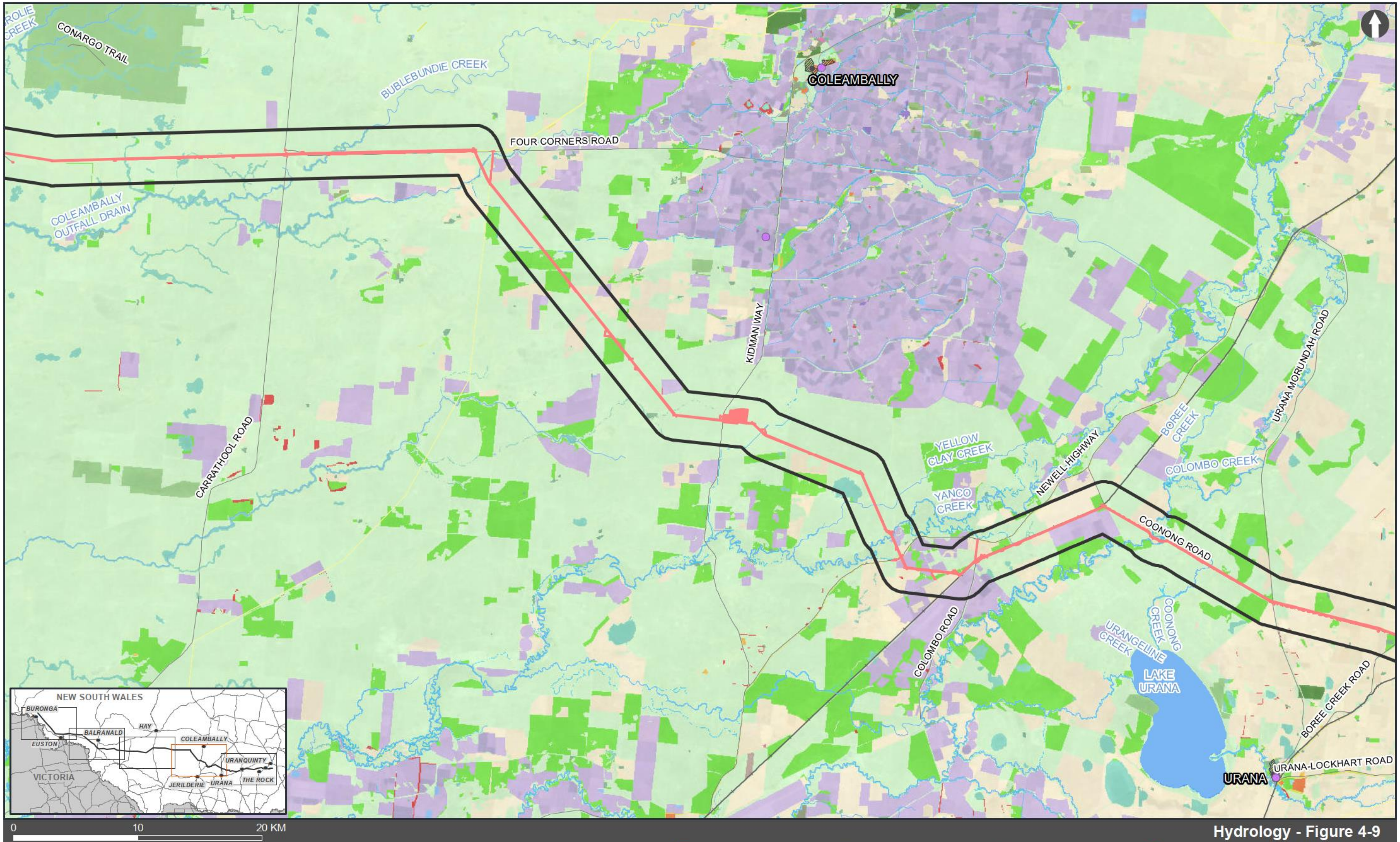
Source: NSWSS, ESRI, Transgrid, WSP



Hydrology - Figure 4-9

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- 3.1.0 Plantation forests
- 3.2.0 Grazing modified pastures
- 3.3.0 Cropping
- 3.4.0 Perennial horticulture
- 4.1.0 Irrigated plantation forests
- 4.2.0 Grazing irrigated modified pastures
- 4.3.0 Irrigated cropping
- 4.4.0 Irrigated perennial horticulture
- 4.5.0 Irrigated seasonal horticulture
- 5.2.0 Intensive animal production
- 5.3.0 Manufacturing and industrial
- 5.4.0 Residential and farm infrastructure
- 5.5.0 Services
- 5.6.0 Utilities
- 5.7.0 Transport and communication
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- 6.2.0 Reservoir/dam
- 6.3.0 River
- 6.4.0 Channel/aqueduct
- 6.5.0 Marsh/wetland

Land Uses in the Study Area

Sheet 4 of 5

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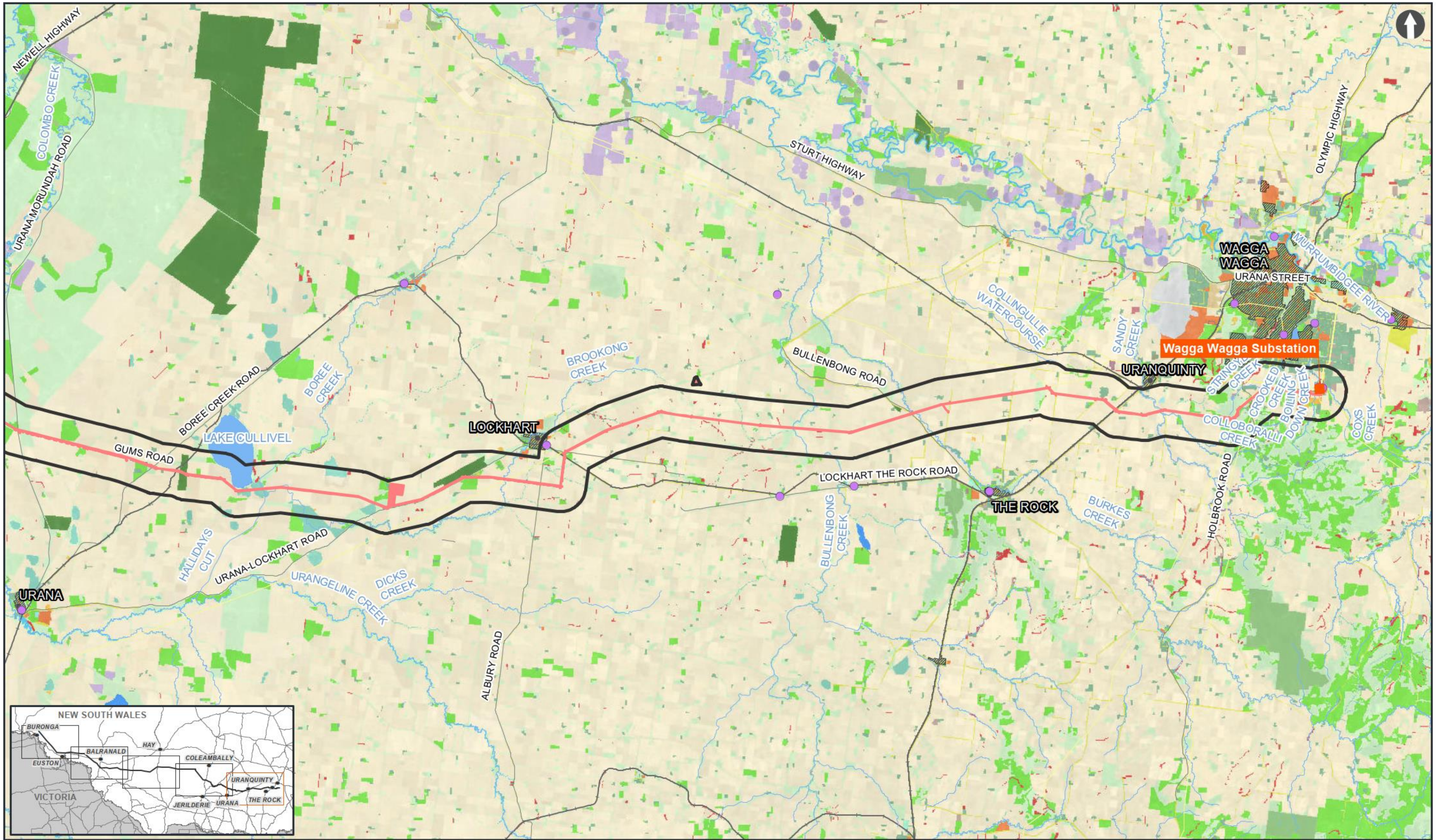
Source: NSWSS, ESRI, Transgrid, WSP



Hydrology - Figure 4-9

Land Uses in the Study Area

Sheet 5 of 5

Project Components

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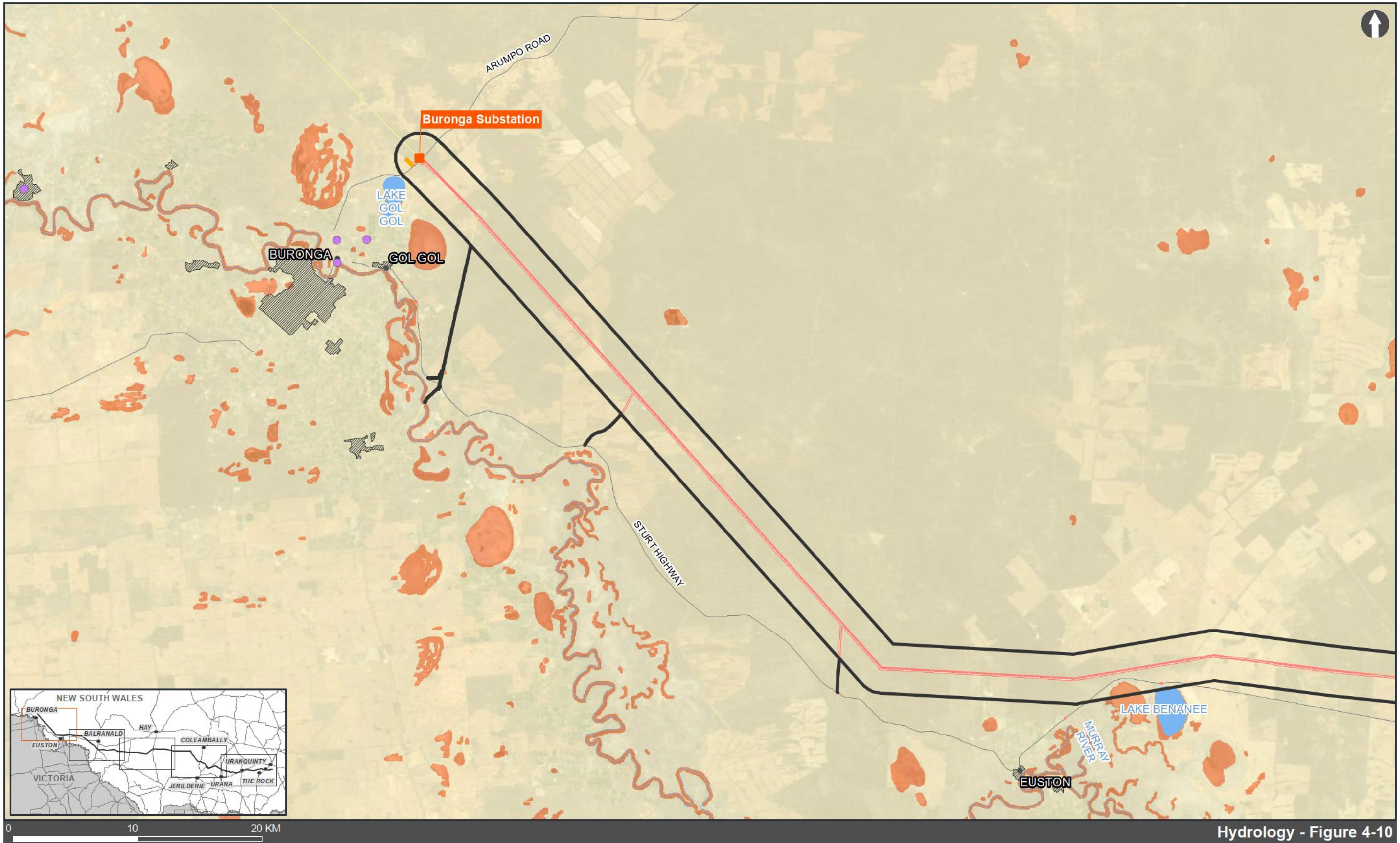


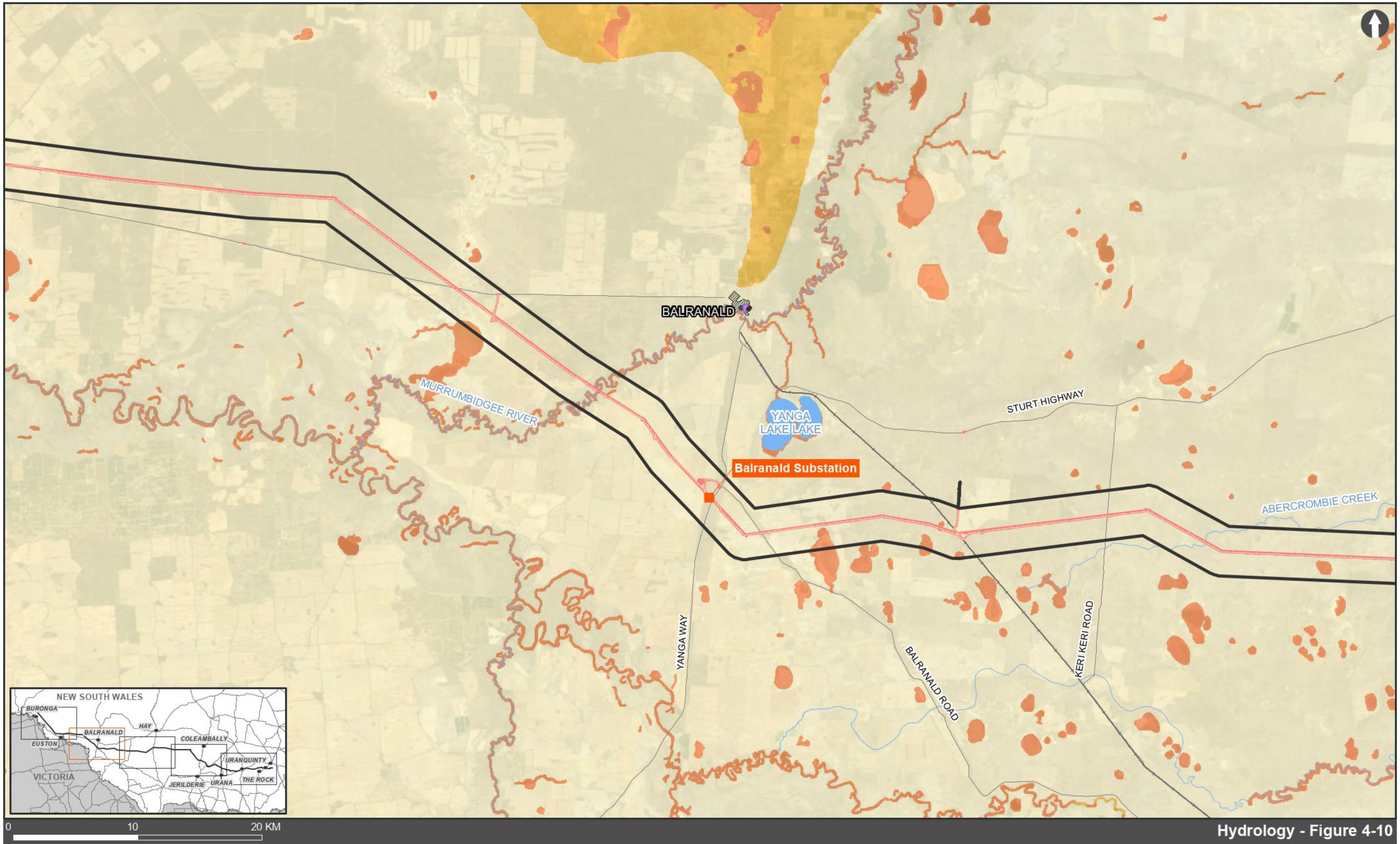
Hydrology - Figure 4-10

Project Components
- Construction Impact Area
- Main Construction Compounds and Accommodation
- Access Tracks
- Water Fill Point
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Surface Water Study Area
- Built Up Areas

Atlas of Acid Sulfate Soils
- High Probability of Occurrence (>70% chance of occurrence)
- Low Probability of Occurrence (6-70% chance of occurrence)
- Extremely Low Probability of Occurrence (1-5% chance of occurrence with occurrences in small localised areas)

Probability of Occurrence of Acid Sulfate Soils in the Study Area

Sheet 1 of 5



Hydrology - Figure 4-10

Project Components
- Construction Impact Area
- Main Construction Compounds and Accommodation
- Access Tracks
- Water Fill Point
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Surface Water Study Area
- Built Up Areas

Atlas of Acid Sulfate Soils
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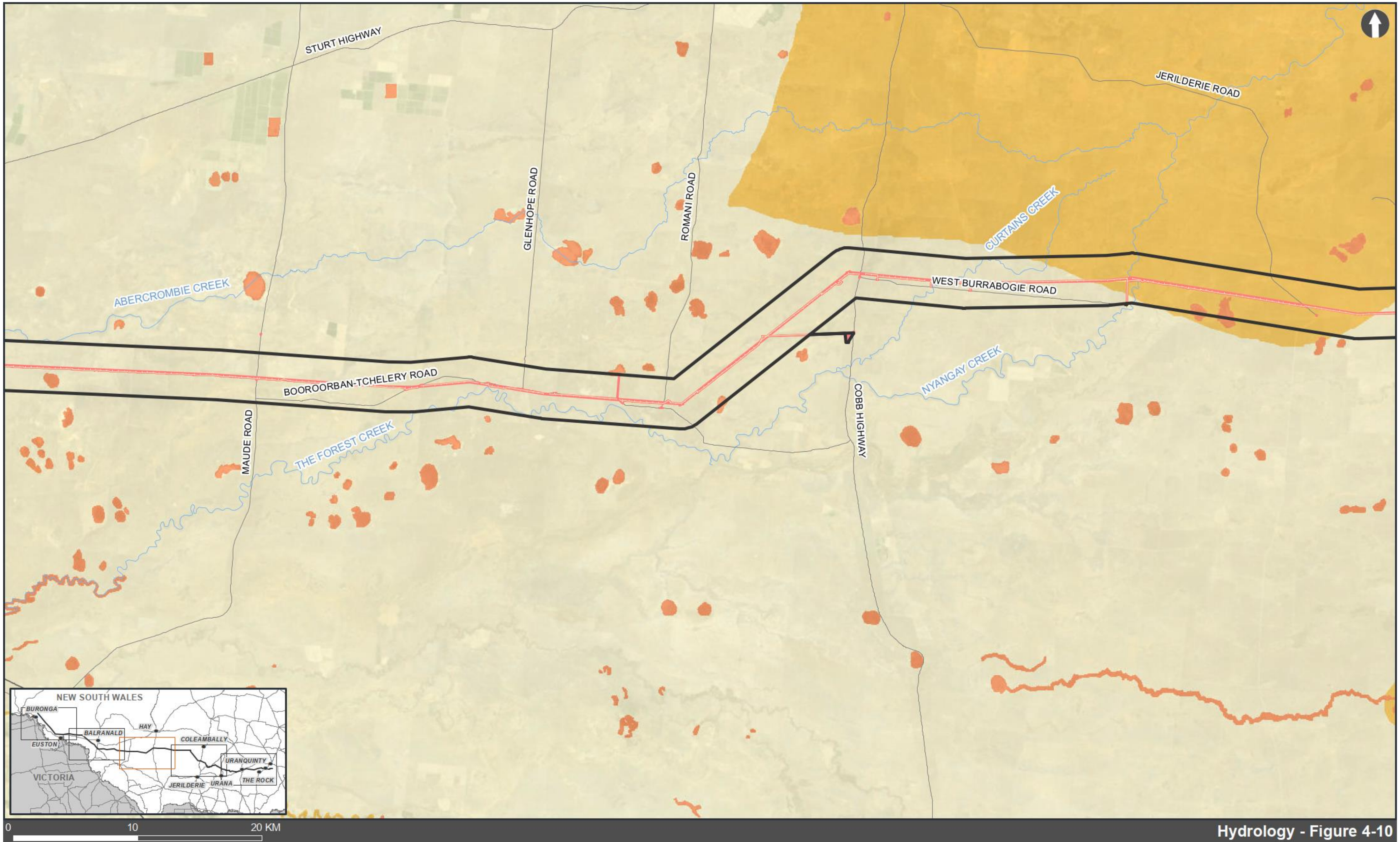
- Low Probability of Occurrence (6-70% chance of occurrence)
- Extremely Low Probability of Occurrence (1-5% chance of occurrence with occurrences in small localised areas)

Probability of Occurrence of Acid Sulfate Soils in the Study Area

Sheet 2 of 5



Hydrology - Figure 4-10

Project Components
- Construction Impact Area
- Main Construction Compounds and Accommodation
- Access Tracks
- Water Fill Point
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Surface Water Study Area
- Built Up Areas

Atlas of Acid Sulfate Soils
- High Probability of Occurrence (>70% chance of occurrence)
- Low Probability of Occurrence (6-70% chance of occurrence)
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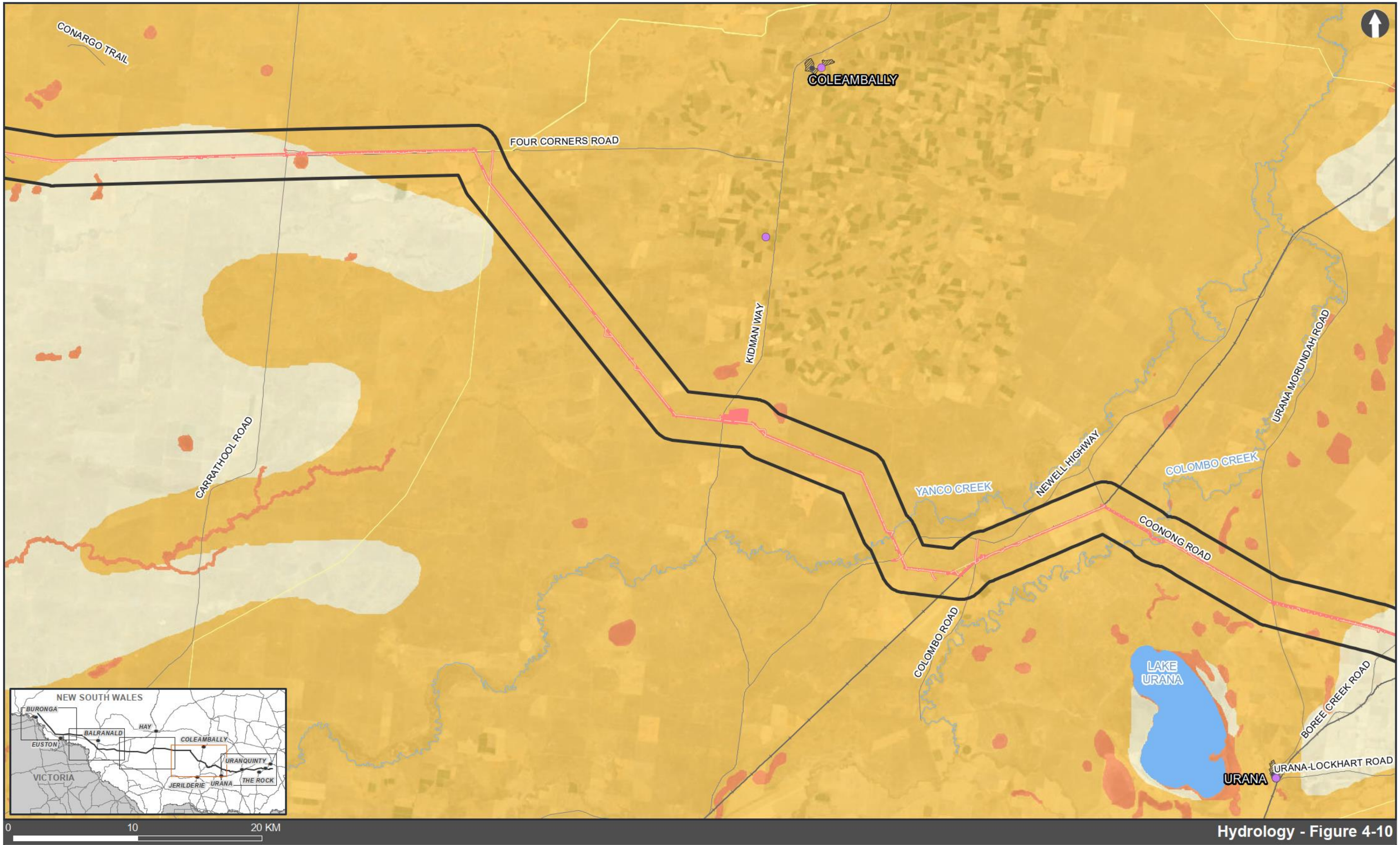
Probability of Occurrence of Acid Sulfate Soils in the Study Area

Sheet 3 of 5



Hydrology - Figure 4-10

Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation
- Access Tracks
- Water Fill Point
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Surface Water Study Area
- Built Up Areas

Atlas of Acid Sulfate Soils

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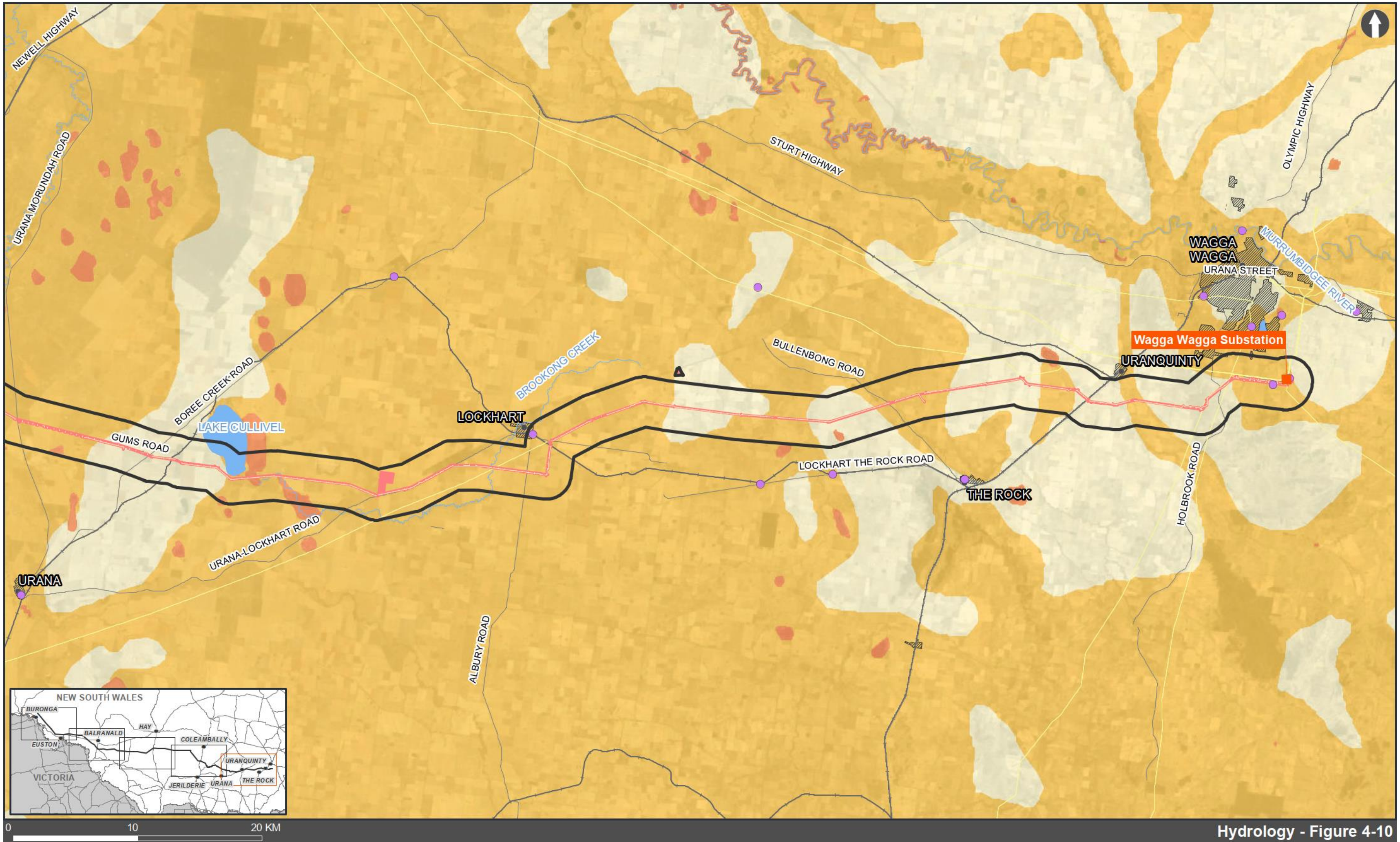
- Low Probability of Occurrence (6-70% chance of occurrence)
- Extremely Low Probability of Occurrence (1-5% chance of occurrence with occurrences in small localised areas)

Probability of Occurrence of Acid Sulfate Soils in the Study Area

Sheet 4 of 5



Hydrology - Figure 4-10

Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation
- Access Tracks
- Water Fill Point
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Surface Water Study Area
- Built Up Areas

Atlas of Acid Sulfate Soils

- High Probability of Occurrence (>70% chance of occurrence)
- Low Probability of Occurrence (6-70% chance of occurrence)
- Extremely Low Probability of Occurrence (1-5% chance of occurrence with occurrences in small localised areas)

Probability of Occurrence of Acid Sulfate Soils in the Study Area

Sheet 5 of 5

4.7.3 Geology

Published geological mapping data from the Seamless Geology Project (Colquhoun, Hughes & Deyssing et al, 2019) identified multiple distinct geological regions across the groundwater study area. The regions broadly correspond to:

- An eastern region that defines the Lake Albert catchment around the Wagga Wagga substation and extends about 10 kilometres west. This region corresponds to an area of varying elevation that ranges from about 200 to 380 metres AHD, where the geology is dominated by outcropping and potentially shallow rock with associated residual and colluvial soils. Alluvium sediments are present and occur at lower elevations (below about 250 metres AHD) and increase in extent north, towards Lake Albert. Locally outcropping granite and aeolian sand plains exist east of the Wagga Wagga substation.
- A region west of the outcropping rock that defines the Lake Albert catchment and extends about 90 kilometres west to Lake Urana. It is dominated by colluvial, residual and aeolian sediments, with localised alluvium and playa lake deposits. Fluvial sediments of the Shepparton Formation exist proximal to Lake Urana.
- A large region that about starts around lake Urana and extends west for 250 kilometres. This region is dominated by the clay rich sediments of the fluvial Shepparton Formation. Localised aeolian lunettes, dunes, claypans and lacustrine deposits, alluvial and aeolian sand plains occur.
- A large region, about 175 kilometres, that extends from Buronga at the western end of the proposal to the region dominated by the Shepparton Formation sediments. This area is dominantly covered by aeolian sand dune fields of the Woorinen Formation. Localised alluvial, fluvial sediments of the Shepparton Formation and playa lake and lacustrine deposits occur.

4.8 Contamination

Table 4-2 provides an overview of the areas of contamination concern, and the associated contaminants, located in or within the vicinity of the hydrology and flooding study area. The identification of areas of contamination concern are based on existing land uses and the potential for contamination to occur. Further discussion regarding potential contamination along the alignment of the proposal is provided in a separate assessment of this EIS, Technical paper 14 – Phase 1 contamination.

Table 4-2 Identified areas of contamination concern within the hydrology and flooding study area

AREAS OF CONTAMINATION CONCERN AND RATIONALE FOR CONCERN		LOCATION	POTENTIAL CONTAMINANTS OF CONCERN
Areas within the hydrology and flooding study area			
Existing transmission line infrastructure	Spills from maintenance activities on site, Asbestos paints on tower infrastructure	Portions of the hydrology and flooding study area	BTEXN TRH Asbestos
Cleared agricultural land	Historical use of pesticides, and foliants, large scale land use and the use of heavy machinery	Portions of the hydrology and flooding study area	Heavy metals, Organochlorine pesticides (OCP) Organophosphorus pesticides (OPP)
Farm dams	Areas of potential contaminant sediment build-up	Portions of the hydrology and flooding study area	Heavy metals OCP OPP Nutrients

AREAS OF CONTAMINATION CONCERN AND RATIONALE FOR CONCERN		LOCATION	POTENTIAL CONTAMINANTS OF CONCERN
Potential quarries	Areas of potential fill	142.440, -34.294	Heavy metals BTEX PAH TRH Asbestos
Potential scaring/ earth works sites	Areas of potential fill	143.345, -34.632 144.978, -34.819 145.659, -34.954 146.327, -35.220 146.667, -35.246 147.387, -35.207 142.430, - 34.281	Heavy metals BTEX PAH TRH Asbestos
Stockpiled material (SMEC 2020)	Fill material of unknown origin and quality	147.129, -35.198 147.074, -35.203	Heavy metals BTEX PAH TRH Asbestos
Waste Management Facility (Wagga Wagga City Council)	Potential fill material of unknown origin and quality, potential leachate and landfill gas	147.379, -35.203	Methane Asbestos Heavy metals BTEX PAH TRH
Outside the hydrology and flooding study area			
PFAS sites (one site located within 1 km of study area).	Potential PFAS contamination of water fill point 100, 102, 104, 105 and 107	147.357, -35.092 147.391, -35.154 147.457, -35.152	PFAS
Service Stations (three located within 500 m of the study area).	Potential petroleum hydrocarbon contamination of water fill points 301, 602 and 603	145.890, -34.805 142.182, -34.174 141.914, -34.103	Heavy metals BTEX PAH TRH

AREAS OF CONTAMINATION CONCERN AND RATIONALE FOR CONCERN		LOCATION	POTENTIAL CONTAMINANTS OF CONCERN
Former Wiradjuri landfill	Potential leachate and landfill gas (under assessment)	147.362, -35.096	Methane Asbestos Heavy metals BTEX PAH TRH

4.9 Groundwater dependent ecosystems

Publicly available location (GIS) data, including information on high priority GDEs, is currently unavailable through the NSW SEED portal for the new water sharing plans that were enacted on 1 July 2020. Nevertheless, an assessment on GDEs from the NGIS database (BOM, 2021) and superseded Water Sharing Plans was conducted and this assessment assumed that the high priority GDEs generally match the location of high potential GDEs recorded in the NGIS database (BOM, 2021b). High potential GDEs are listed in Table 4-3.

Table 4-3 GDEs with high potential for groundwater interaction within the groundwater study area (BOM, 2021b)

GDE TYPE	NAME
Aquatic	Coloboralli Creek
Aquatic	Stringybark Creek
Aquatic	Boiling down Creek
Aquatic	Crooked Creek
Aquatic	Sandy Creek
Aquatic	Lake Cullival
Aquatic	Wetlands
Terrestrial	River Red Gum
Terrestrial	Red River Gum and Warrego Grass
Terrestrial	Red River Gum and Wallaby Grass
Terrestrial	Red River Gum and Lignum
Terrestrial	Red River Gum and Black Box
Terrestrial	Lignum shrubland
Terrestrial	Black box
Terrestrial	Canegrass Swamp
Terrestrial	Dillon bush (Nitre bush)
Terrestrial	Nitre Goosefoot shrubland

4.10 Wetlands

The Protected Matters Search Tool (NSW DAWE, 2020) identified no RAMSAR wetlands within the hydrology and flooding study area.

The Lowbidgee Floodplain is a significant wetland area within the Murrumbidgee catchment (Department of Agriculture, Water and the Environment, 2020). The wetlands support large numbers of waterbirds, many of which breed in the extensive lignum swamps, and provide habitat for many threatened species.

4.11 Groundwater interaction

There is limited groundwater connectivity to surface water features within the study area. Surface water features (streams, rivers, creeks and lakes) are ephemeral and receive the majority of available water from upstream, particularly within the Murrumbidgee Alluvium and Porous rock hydrostratigraphic units. None of the assessed groundwater sources are classified as highly connected to surface water sources. Refer to Technical paper 15 – Groundwater impact assessment for further description.

4.12 Geomorphology

Table 4-4 outlines the geomorphology of the watercourses intersected by the hydrology and flooding study area. This assessment is based on the NSW River Styles Mapping (NSW Department of Industry, 2019a). There are many dry watercourses and overland flow paths intersected by the hydrology and flooding study area that are not identified as watercourses and therefore have not been assessed individually. Many of these watercourses would be first order streams (meaning there are no other streams flowing into it) and their size, shape and location is dependent on regular rainfall events. There are also many second and higher order streams that have not been officially identified and these streams are dependent on the first order streams for surface flows.

The geomorphic condition affects the aquatic biodiversity and physical habitats available in the stream. The riverine channel and bank shape and riparian vegetation is used to assess the local aquatic habitat and its potential to support aquatic biota and these physical features and stream order form the basis of the NSW River Styles Mapping. The lack of regular flow and no riparian vegetation mean the first and second order streams or overland flow paths would be in a poor geomorphic condition (no fixed channel shape or size) and high fragility because of the significant potential to change with each flow event.

In Table 4-4 recovery potential is a measure of the capacity of a reach to return to good condition or to a realistic rehabilitated condition, given the limiting inputs of the reach. These inputs include the flow volumes and velocities and the type of vegetation and sediments the help maintain the stream style.

Table 4-4 Watercourses in the hydrology and flooding study area and the associated NSW River Styles Mapping information

WATERCOURSE	STREAM ORDER	NSW RIVER STYLE	EXISTING CONDITION	RECOVERY POTENTIAL
Box Creek	8	Valley fill, fine grained	Good condition High fragility	Conservation
Murrumbidgee River	9	Meandering, fine grained	Moderate condition Low fragility	Moderate
Condoulpe Creek	2	Valley fill, fine grained	Moderate condition High fragility	Moderate

WATERCOURSE	STREAM ORDER	NSW RIVER STYLE	EXISTING CONDITION	RECOVERY POTENTIAL
Abercrombie Creek	9	Valley fill, fine grained	Moderate condition High fragility	Moderate
The Forest Creek	9	Valley fill, fine grained	Moderate condition High fragility	Moderate
Curtains Creek	9	Valley fill, fine grained	Moderate condition High fragility	High
Nyangay Creek	9	Valley fill, fine grained	Moderate condition High fragility	High
Eurolie Creek	4	Valley fill, fine grained	Moderate condition High fragility	High
Bublebundie Creek	1	Valley fill, fine grained	Moderate condition High fragility	Moderate
Yellow Clay Creek	2	Anabranching, valley setting, continuous	Moderate condition Low fragility	Moderate
Yanco Creek	9	Meandering, fine grained	Moderate condition Low fragility	Moderate
Brookong Creek	5 and 4	Low sinuosity, fine grained	Moderate condition Low fragility	Moderate
Bullenbong Creek	6	Valley fill, fine grained	Moderate condition High fragility	Moderate
Burkes Creek	6	Low sinuosity, fine grained	Moderate condition Moderate fragility	Moderate
Coloboralli Creek	Null	Low sinuosity, fine grained	Poor condition Moderate fragility	Low
Crooked Creek	5	Low sinuosity, sand	Poor condition High fragility	Low
Boiling Down Creek	4	Channelised fill	Poor condition Moderate fragility	Low

4.13 Water quality

A desktop review was undertaken of existing water quality conditions. Water quality data and documents (refer to section 3.5) from the broader catchment areas was reviewed to provide an understanding of the general water quality of the hydrology and flooding study area.

4.13.1 State of the Catchments (2010)

The 2010 State of the Catchments reports (NSW Government, 2010) documented the condition of, and pressures on, 13 catchments under the NSW Monitoring Evaluation and Reporting program.

The reports used turbidity and total phosphorus (TP) as indicators of water quality performance for all catchments for the period from 2005-2008. For the Murrumbidgee catchment, water quality results were varied across the catchment. The monitoring site at the Murrumbidgee River Downstream of Wagga Wagga at Roach Road reported that 76% of samples exceeded the limits for TP. Sites at Colombo Creek at Morundah and Yanco Creek at Morundah had 59% and 52% exceedances respectively, whereas the Balranald Weir site recorded only 3% exceedances.

4.13.2 National Water Quality Assessment (Sinclair Knight Merz, 2011)

The National Water Quality Assessment (Sinclair Knight Merz, 2011) was commissioned as a nationwide water quality assessment to provide a snapshot of water quality across inland waters of Australia. The assessment collated water quality data from a series of sources across Australia and compared them to the relevant ANZECC 2000 water quality objectives for the region. The water quality data examined in the assessment included turbidity, salinity, pH, nutrients and algal blooms (specifically cyanobacterial blooms), and faecal contamination (microbial quality). The report classified water quality for each of these parameters between ‘very poor’ to ‘good’ based on the percentage of samples that were compliant with the ANZECC 2000 objectives. These classifications are shown in Table 4-5.

Table 4-5 National Water Quality Assessment 2011 – Water quality classifications against ANZECC 2000 guidelines

CLASSIFICATION	PERCENTAGE COMPLIANCE WITH ANZECC 2000 GUIDELINES VALUES
Good	>75%
Fair	50–75%
Poor	25–50%
Very Poor	<25%

Water quality in the Mid Murray catchment was generally good with turbidity, salinity, pH and nutrients complying for ANZECC/ARMCANZ (2000) guidelines for most samples. Twenty sites were included in the water quality assessment in this catchment, two of which rated ‘fair’ for turbidity and pH, with all other samples rating ’good’.

Water quality data in the Murrumbidgee River catchment from 70 sites in NSW were suitable for inclusion in the National Water Quality Assessment 2011. Three water quality variables (turbidity, salinity and pH) rated ‘good’ as greater than 75 percent of samples complied with the ANZECC/ARMCANZ (2000) guidelines for south-east Australia. Turbidity was generally low with 12 percent of samples exceeding the relevant guideline value (although this was highly variable across the river basin).

Salinity was also generally higher in tributaries to the Murrumbidgee River including Billabong Creek, Houlaghans Creek, Muttama Creek and Jugiong Creek. Nutrients exceeded the guidelines and generally had fair to poor compliance. For these tributaries, total nitrogen was rated ‘poor’ (74 percent of samples exceeded the guideline) and TP was rated ‘fair’ (50 percent of sampled exceeding the guideline).

4.13.3 State of the environment 2018 (EPA, 2018)

Prepared every three years, the NSW State of the Environment (SoE) reports on the status of key environmental issues facing New South Wales including waterway health. This report uses the same classifications for water quality samples as shown in Table 4-5. Figure 4-11 shows a summary of the monitoring sites used for the SoE 2018 and the percentage of samples from each site that exceed the ANZECC 2000 water quality objectives. The SoE 2018 reported on only nutrients TN and TP.

The figure shows that sampling sites on the Murrumbidgee River between Yanco Creek and the Lachlan River have 'good' to 'fair' ratings for TN and TP (as per the rating described in Table 4-5 above). The site on the Murrumbidgee River located just upstream of the confluence with the Murray recorded 'fair' ratings for both TP and TN and the site at the confluence of the Murray and the Murrumbidgee Rivers has a 'good' rating for TN and 'Fair' for TP.

Four of five sites located on Yanco Creek have 'very poor' ratings for TP and 'fair' to 'very poor' ratings for TN.

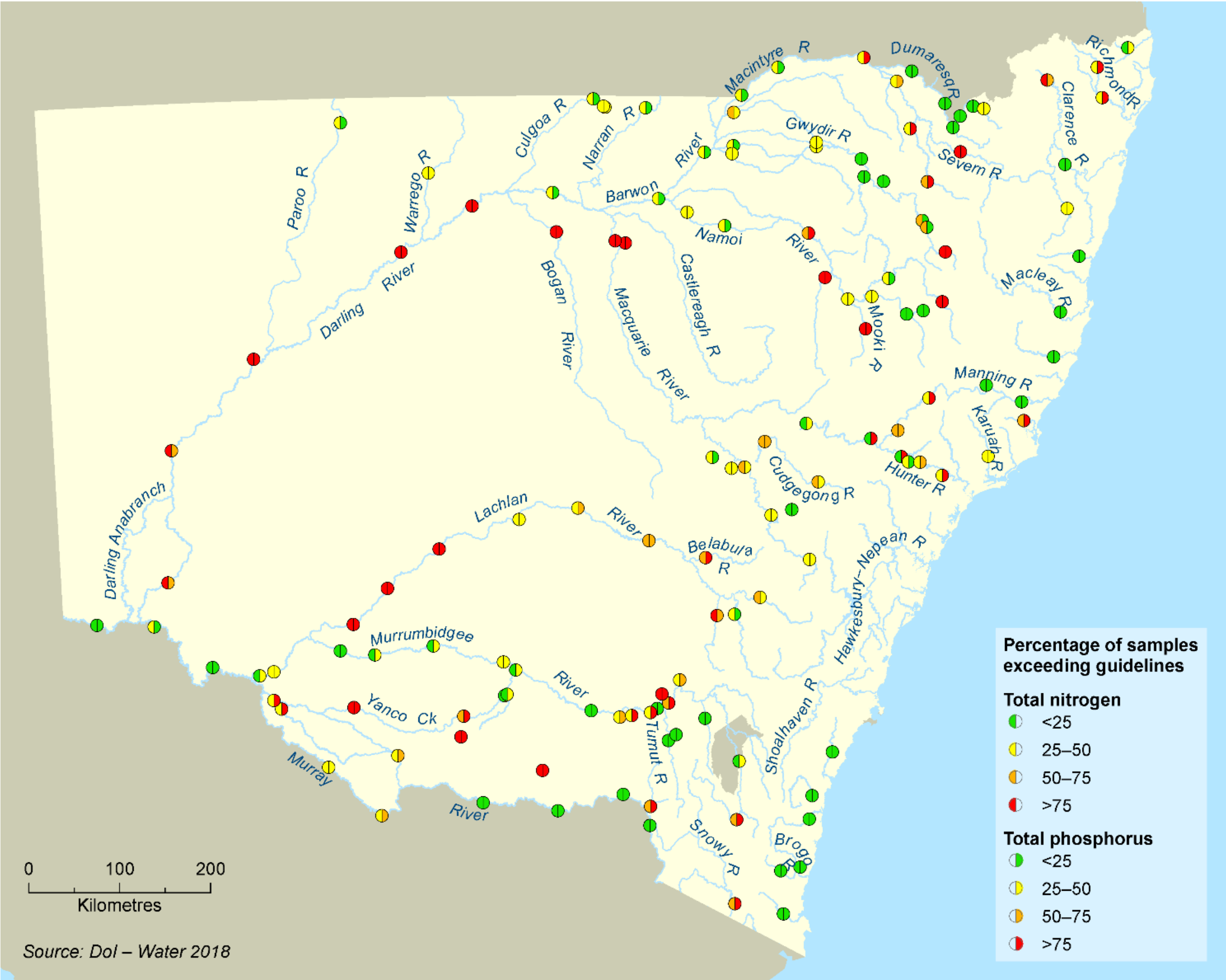


Figure 4-11 Percent of samples exceedances for nutrient values as assessed by the 2018 State of the Environment report

4.13.4 Darling Water Resource Plan, (DPI, 2018)

The Darling Water Resource Plan (DPI, 2018) rated the condition of the Lower Murray-Darling as poor to good using an integrated indicator of TN, TP, pH, turbidity and dissolved oxygen. The indicator was calculated using the frequency and amplitude of exceedances of the Basin Plan 2012 water quality targets during 2010–11 and 2014–15.

The monitoring site closest to the hydrology and flooding study area on the Murray River at Lock 8 was rated as 'good'. Nutrients (nitrogen and phosphorus) and suspended sediments are mostly low in the Murray River.

WaQI Scores: Blue = Excellent (100-95), Green = Good (94-80), Orange = Fair (79-60), Red = Poor (59-1).

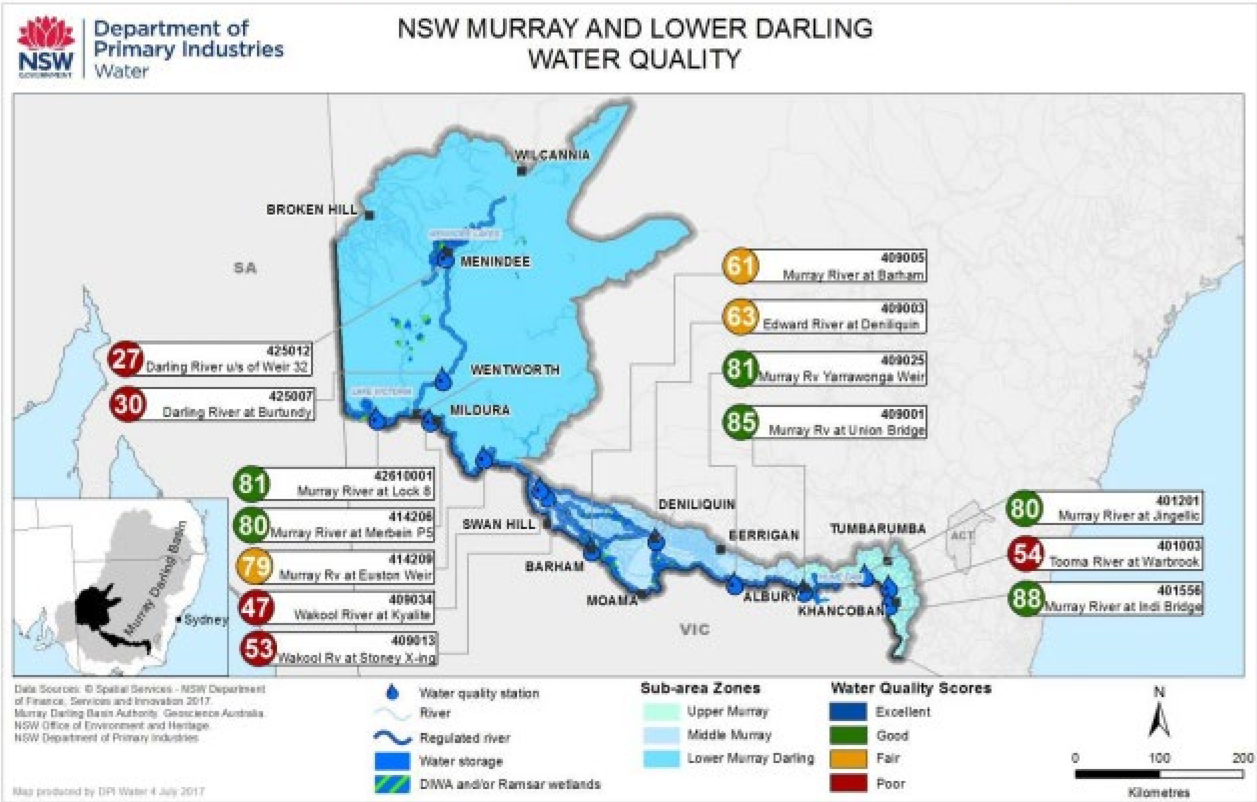


Figure 4-12 Water quality ratings – Darling Water Resource Plan, DPI, 2018

4.13.5 Murrumbidgee Water Resource Plan, 2019

The Murrumbidgee Water Resource Plan (DPI, 2019) rated the condition of the Murrumbidgee River catchment as 'poor' to 'fair using an integrated indicator of TN, TP, pH, turbidity and dissolved oxygen. Water quality conditions in the Murrumbidgee River catchment varies from poor to excellent.

The report noted that water quality attributes in the Murrumbidgee are related to flow. High flow from rainfall and runoff resulted in higher turbidity, nutrients and possibly pesticides and pathogens, but lower electrical conductivity (in stream salinity). There is also a general trend towards increasing turbidity concentration with distance down the catchment. This shows the cumulative impacts of land use, soil disturbance and human activity on water quality. In the lower Murrumbidgee the report notes electrical conductivity is generally considered excellent and rarely exceeds targets even during low flows.

The sites closest to the hydrology and flooding study area include site the Murrumbidgee near Balranald (site 41010901) which received a 'fair' water quality rating, Yanco Creek at Yanco Bridge (site 410169) received a 'poor' rating, Yanco Creek at Morundah (site 410015) rated 'fair' and Murrumbidgee River downstream of Wagga Wagga (site 41041395) which rated 'good'. The water quality at these sites was very good in terms of pH levels and generally fair with regard to total nitrogen.

At Yanco Creek at Yanco Bridge and at Morundah the water quality scores for total phosphorus and turbidity were 'poor'. The Dissolved Oxygen score at Yanco Creek at Yanco Bridge was also 'fair; however this score was 'good' at Morundah (NSW DPIE, 2020)

The report also commented that in unregulated greater focus should be given to land, soil and vegetation management to prevent sediment and nutrients from entering waterways as sediment is a major transport mechanism for many pollutants.

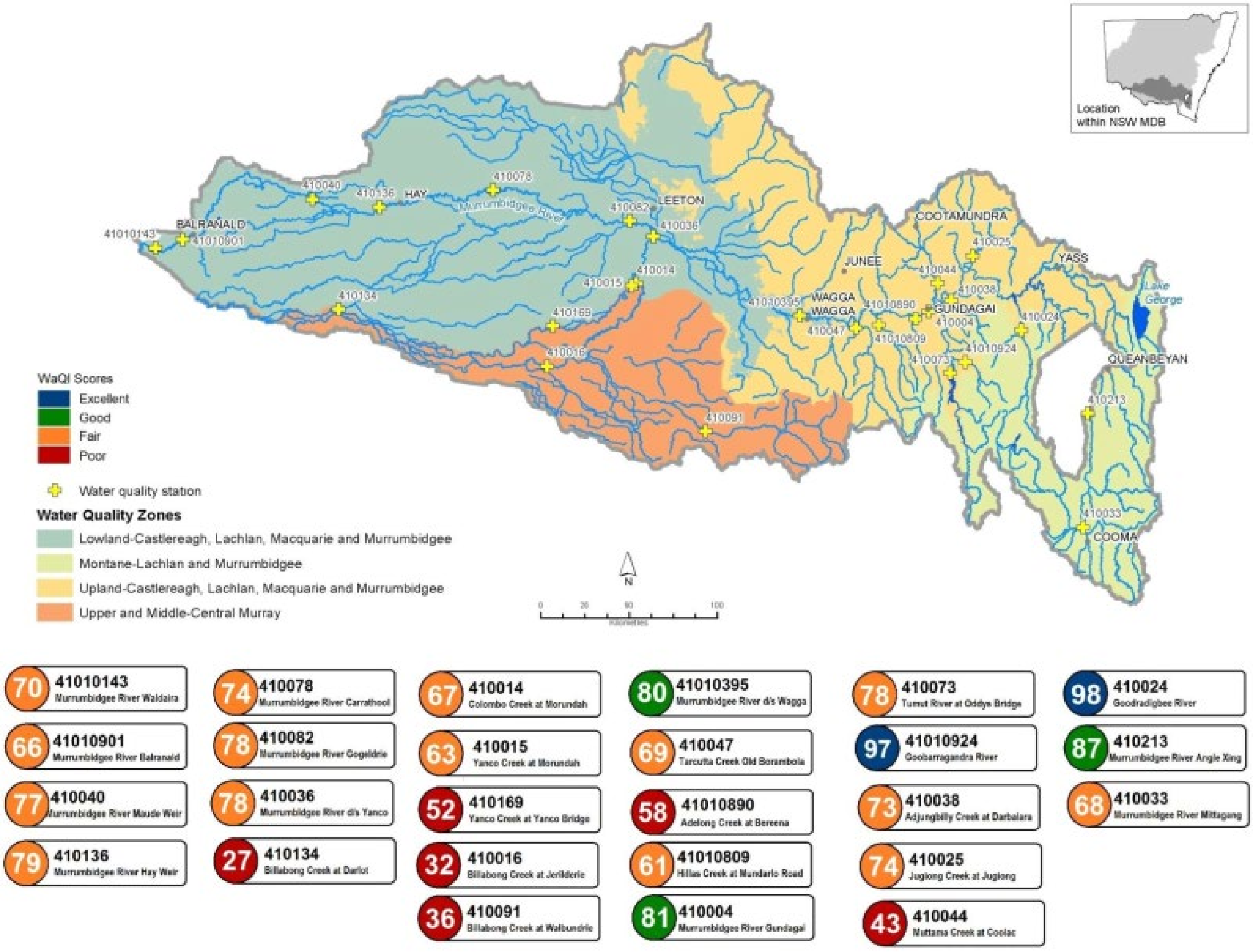


Figure 4-13 Water quality ratings – Murrumbidgee Water Resource Plan, DPI, 2019

4.13.6 Other water quality data

Data from four sites near Wagga Wagga on the Murrumbidgee River, Tarcutta and Billabong Creek was extracted from the Real-time Data website (WaterNSW, 2021) as shown in Table 4-6. Monitoring 410048 at Ladysmith at Kyeamba Creek is located downstream to the north of the proposal site at Wagga Wagga. Site 410186 at Billabong Creek downstream of Ten Mile & Mountain Creeks, station 410001 at Wagga Wagga on the Murrumbidgee, and 410017 at Old Borambola on Tarcutta Creek are is located upstream of the proposal site. The locations of these monitoring sites are shown on Figure 4-14.

Table 4-6 shows the minimum, mean and maximum values for electrical conductivity (EC) and turbidity for the available monitoring periods at these monitoring sites. Electrical conductivity is the only value that was monitored consistently at all sites. These values were taken on a monthly basis beginning in May 1993 (site 410001), December 2000 (site 410048) and February 2002 (site 410047) up until 2021. It is noted that data sets were not complete for the time periods monitored.

Table 4-6 Water quality monitoring data on the Murrumbidgee River near Wagga Wagga

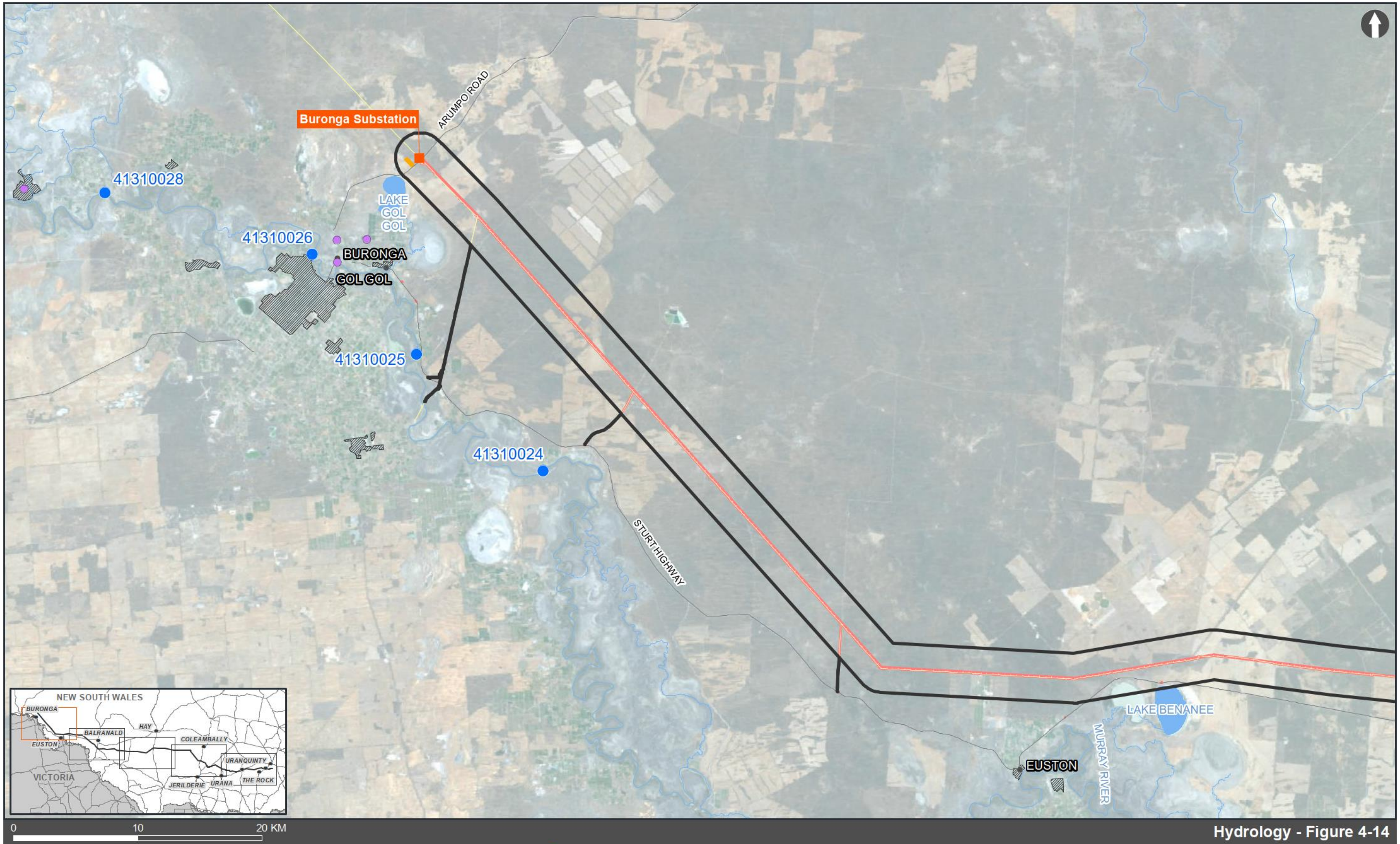
		MURRUMBIDGEE RIVER AT WAGGA WAGGA	TARCUTTA CREEK AT OLD BORAMBOLA	KYEAMBA CREEK AT LADYSMITH
Site ID		410001	410047	410048
Location		-35.10080647, 147.36759317	-35.1623, 147.6555	-35.19559444, 147.510544
EC Target peak (80%ile): 258 µS/cm	Min	30.0	35.9	20.8
	Mean	142.0	266.8	733.7
	Max	309.4	727.4	2109.2
Turbidity Target: 35-50 NTU	Min	3.7	–	-1
	Mean	71.6	–	54.6
	Max	316.6	–	131.4

The monitoring data shows that the mean EC values on the Murrumbidgee and at Tarcutta Creek were below or close to the target values given under the Murray Darling Basin Plan (refer to Section 2.2.2.1). The mean EC values at Kyeamba Creek and Billabong Creek were both two to three times the target EC values.

Turbidity data was only available at the Murrumbidgee River site and Kyeamba Creek site. Turbidity was monitored intermittently at site 410001 at Wagga Wagga on the Murrumbidgee between June 1993 and February 2012. Twelve samples of turbidity were available from site 410048 at Ladysmith at Kyeamba Creek between December 2004 and June 2010. The mean turbidity values for these sites were above the target values.

The Murrumbidgee River At Downstream Balranald Weir site (number 410130) recorded data for EC and dissolved oxygen. This site is located upstream of the hydrology and flooding study area on the Murrumbidgee River near its confluence with the Murray River at Balranald. The average EC value at this site was 153 µS/cm which is below the target peak value of 258 µS/cm for the Castlereagh, Lachlan, Macquarie and Murrumbidgee (A3). The average dissolved oxygen value was 8.5 mg/L which achieves the target value of greater than 7 mg/L for the A3 water quality zone.

Data from four sites on the Murray River near Mildura were also extracted from the Real-time Data website (WaterNSW, 2021) as shown in Table 4-7. These stations are all located to the west of the proposal on the Murray River, downstream of the proposal site. Table 4-7 shows the minimum, mean and maximum values for EC for the available monitoring periods at these monitoring sites. These values were taken from January 2013 to January 2015 at all sites except site 41310028, and a few additional measurements in 2018 up until 2020. Site 41310028 recorded measurements one measurement a year in 2007 and from 2009 to 2015.



Hydrology - Figure 4-14

Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation Sites
- Access Tracks
- Water Fill Point
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Surface Water Study Area
- Built Up Areas
- Water Monitoring Sites

Water Monitoring Stations Near the Proposal Area

Sheet 1 of 5

Source: NSWSS, ESRI, Transgrid, WSP

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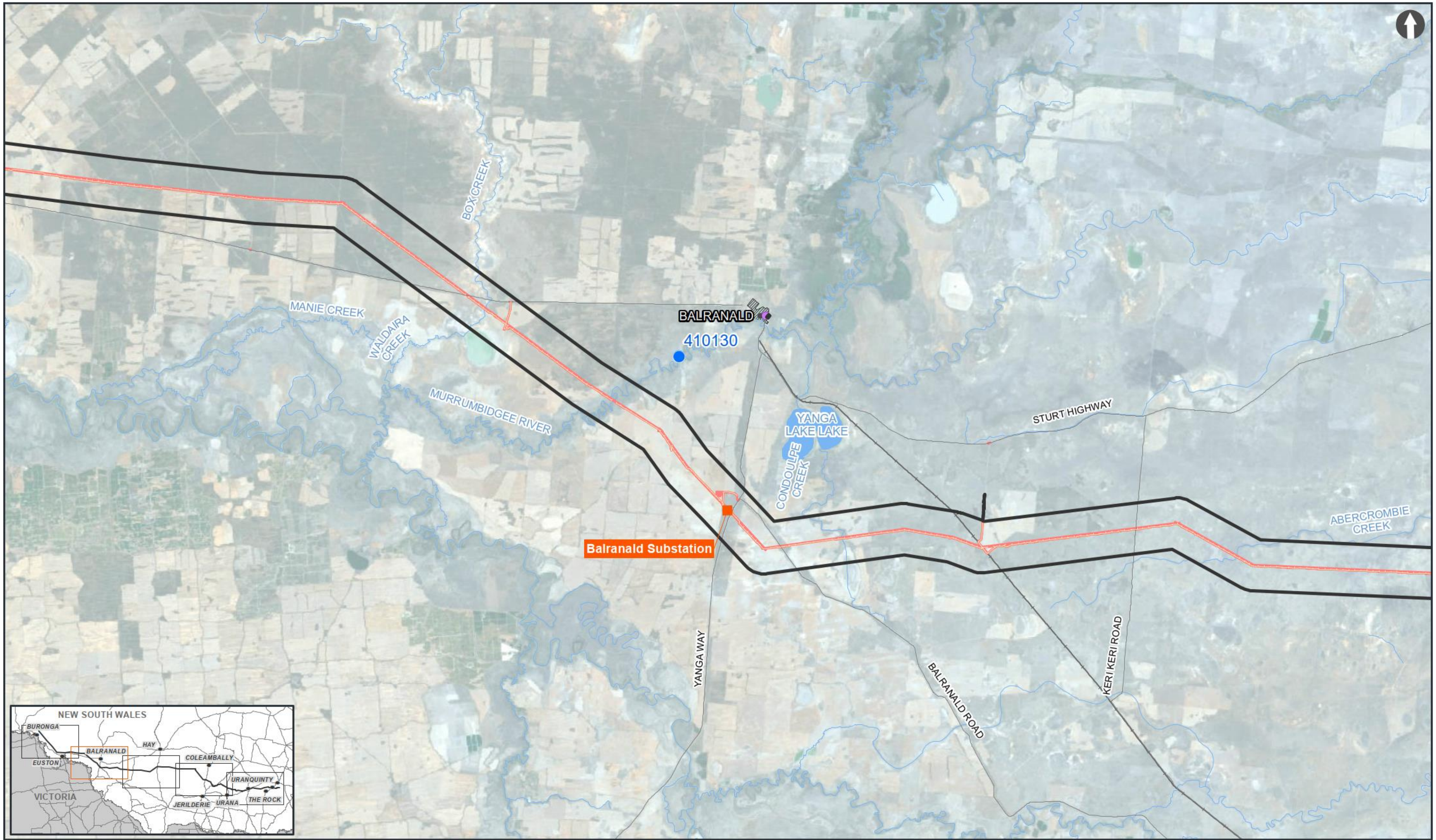

Hydrology - Figure 4-14

Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation Sites
- Access Tracks
- Water Fill Point
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Surface Water Study Area
- Built Up Areas
- Water Monitoring Sites

Water Monitoring Stations Near the Proposal Area

Sheet 2 of 5

Source: NSWSS, ESRI, Transgrid, WSP

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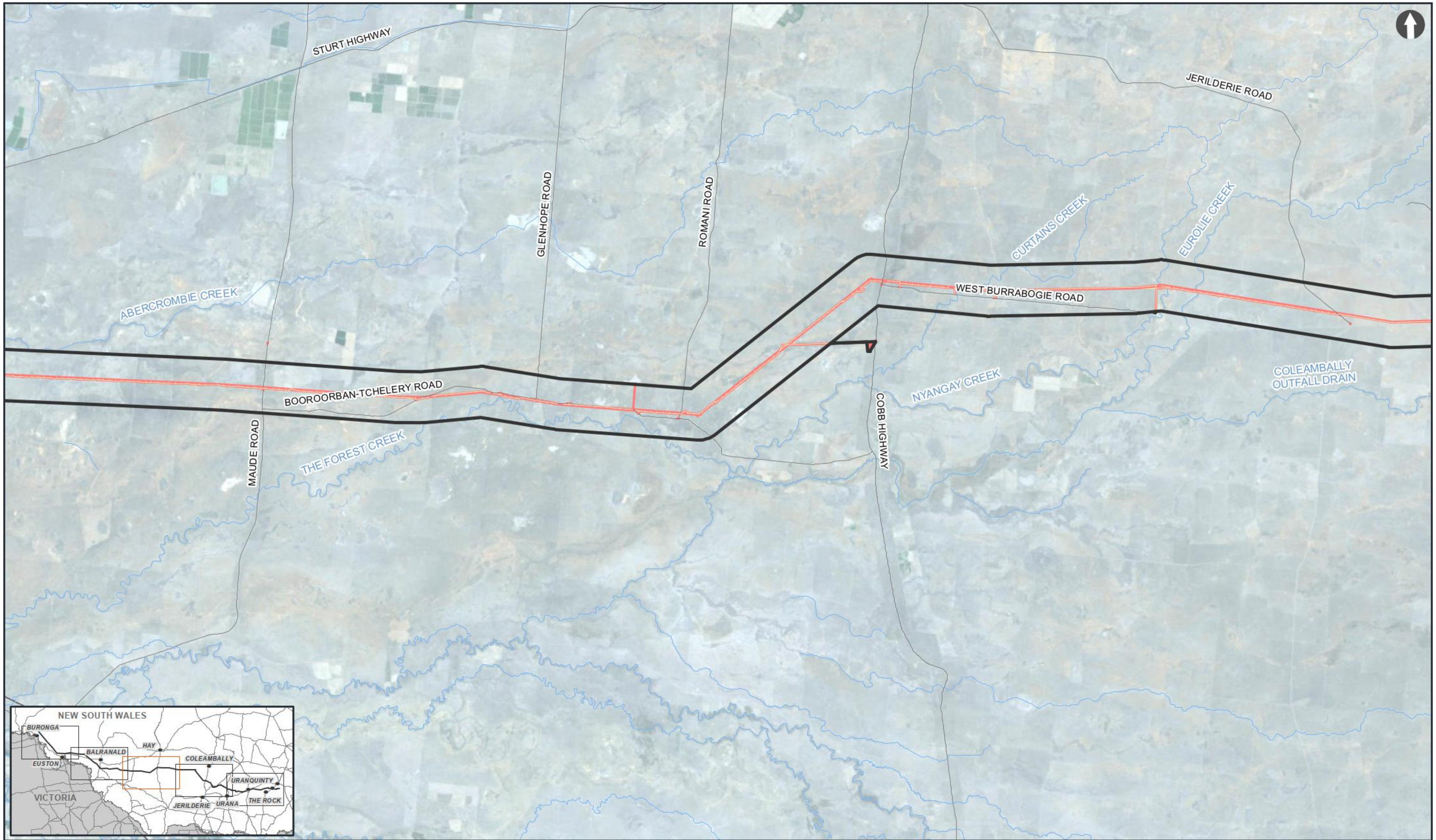

Hydrology - Figure 4-14

Water Monitoring Stations Near the Proposal Area

Sheet 3 of 5

Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation Sites
- Access Tracks
- Water Fill Point
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Surface Water Study Area
- Built Up Areas
- Water Monitoring Sites

Source: NSWSS, ESRI, Transgrid, WSP

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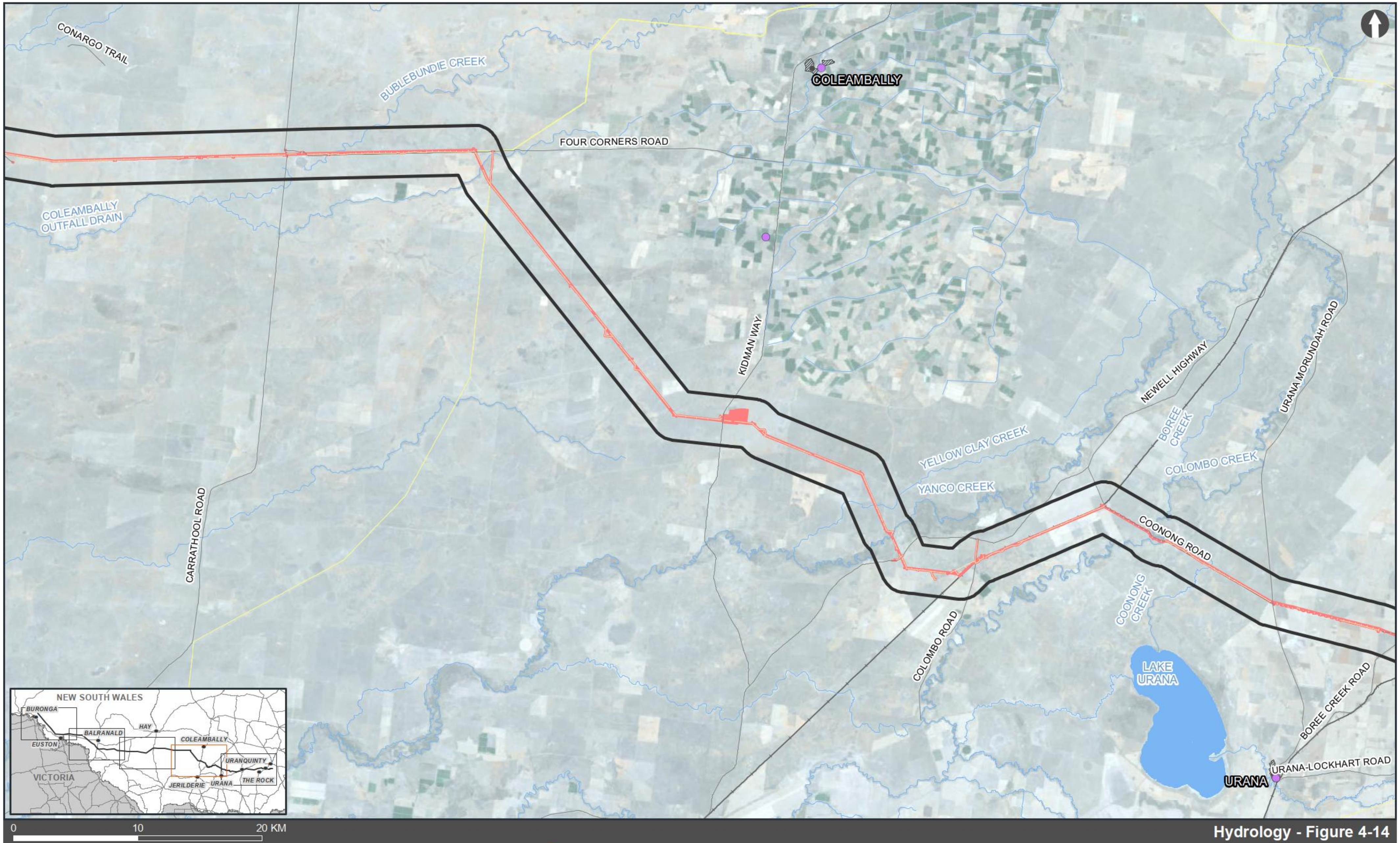

Hydrology - Figure 4-14

Water Monitoring Stations Near the Proposal Area

Sheet 4 of 5

Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation Sites
- Access Tracks
- Water Fill Point
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Surface Water Study Area
- Built Up Areas
- Water Monitoring Sites

Source: NSWSS, ESRI, Transgrid, WSP

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Hydrology - Figure 4-14

Water Monitoring Stations Near the Proposal Area

Sheet 5 of 5

Project Components

- Construction Impact Area
- Main Construction Compounds and Accommodation Sites
- Access Tracks
- Water Fill Point
- Existing Transmission Line Infrastructure
- Existing Substation
- Existing Railway
- Surface Water Study Area
- Built Up Areas
- Water Monitoring Sites

Source: NSWSS, ESRI, Transgrid, WSP

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Table 4-7 Water quality monitoring data on the Murray River near Mildura

		MURRAY RIVER AT MALLEE CLIFFS DOWNSTREAM PONTOON	MURRAY RIVER AT RED CLIFFS PONTOON	MURRAY RIVER AT CHAFFEY'S GRAVEYARD PONTOON	MURRAY RIVER AT CURLWAA PONTOON
Site ID		41310024	41310025	41310026	41310028
Location		-34.3351, 142.3473	-34.2442, 142.2445	-34.1666, 142.1602	-34.111, 141.9843
EC Target peak (80%ile): 412 µS/cm	Min	104.5	99.3	125.1	119.1
	Mean	114.8	125.3	135.9	145.5
	Max	132	145.5	152.7	177

The monitoring data shows that the mean EC values at these sites were consistently below the target value of 412 µS/cm for this water quality zone (CMum) given under the Murray Darling Basin Plan for the Lower Murray (refer to Section 2.2.2.1).

4.13.7 Summary of existing water quality

The reviewed reports have used the ANZECC 2000 guideline trigger values, now the ANZG guideline values, to assess water quality condition. The water quality targets presented in the Murray and Lower Darling Surface Water Resource Plan – Water Quality Management Plan were developed following the methods outlined in the ANZECC 2000 guidelines, the previous water quality provide an indication of the likely condition of the existing water quality environment of the hydrology and flooding study area.

The National Water Quality Assessment (Section 4.13.2) noted that water quality values in the Mid Murray were often 'good'. The State of the Catchments report noted that the water quality values in the Murrumbidgee catchment were variable with high level of exceedances in some locations and very lower levels of exceedances in other locations, particularly for TP. Additionally the National Water Quality Assessment 2011 reported generally good values for water quality indicators of turbidity, salinity and pH in the Murrumbidgee catchment but not for nutrients.

The 2018 State of the Environment Report (Section 4.13.3) scored an overall rating of the Murray River as 'good'. The same report recorded varied values in the Murrumbidgee catchment, however monitoring site values on the Murrumbidgee River were generally 'good' to 'fair' for nutrient values, whereas monitoring values on tributaries to the Murrumbidgee such as Yanco Creek were generally 'poor' to 'very poor'.

Overall, it is noted that water quality in the catchment is varied. Generally, water quality on the major rivers of the Murrumbidgee and Murray Rivers is better than in associated tributaries. Within and downstream of the study area, the Murrumbidgee and Murray Rivers commonly achieve the existing water quality targets outlined in Table 2-2. Typically, where exceedances have been recorded, these are in relation to nutrients, particularly phosphorus and turbidity in tributaries to the major rivers.

There is limited water quality data available for watercourses along the alignment of the proposal. Given the high proportion of agricultural land within the hydrology and flooding study area, it is likely that some waterways near the proposal would not achieve the water quality criteria as laid out in the ANZG 2018 and Murray Darling Basin Plan 2012, particularly for nutrients. The sources of the high nutrient levels are likely to be diffuse and related to current and historical agricultural activities within the hydrology and flooding study area.

4.14 Sensitive receivers

Sensitive receivers include both human related and environment related receivers. Within the surface water and hydrology study area the identification of receivers has been limited to the construction zone.

Human sensitive receivers include residential buildings and other buildings such as commercial buildings and farm buildings. From a review of the available aerial photography no residential or other buildings have been identified within the project easement nor within the construction zone.

Environmental sensitive receivers include surface water features such as rivers, creeks, wetlands and groundwater dependent ecosystems. These have been identified and discussed in Section 4.4, 4.9, 4.10 and 4.12 above.

5 Assessment of construction impacts

5.1 Flooding

During construction, the impacts to flood behaviour are likely to be temporary, localised and insignificant. The following construction activities have been considered:

- construction of access tracks for construction machinery and materials to access each transmission line tower site
- earthworks and establishment of construction pads for each transmission line tower
- construction of footings and foundation works for the new transmission line towers including boring and/or excavation, steel fabrication works and concrete pours
- construction works at the proposed brake/winch sites
- construction of the proposed Dinawan 330kV substation
- upgrade and expansion of the existing Wagga Wagga substation
- establishment of construction compounds and accommodation camps, laydown and staging areas and concrete batching plants.

The main risk of potential flooding impacts would occur where the proposal is being constructed within the vicinity of existing waterways. Generally, the design of the transmission line would include a transmission line tower on either side of each major river crossing. A drone would be used to take a lead wire over the river or, in some cases alternative methods, such as the use of watercraft, may be used. This methodology would therefore limit the need to create temporary structures that may have the potential to impact on flows from flooding events during the construction period.

Some temporary crossings may be needed for smaller tributaries that have dry creek beds and which would require long journeys to divert construction vehicles around the crossing. In wet weather events these, crossing could become unusable or, if small embankments are placed in the waterway during construction to allow for vehicle crossings, then they could result in minor increases in flood levels upstream of the crossing. These minor increases would be temporary but have the potential to cause disturbance of the waterways if suitable crossing infrastructure is not included.

The earthworks required for each transmission line tower would also have the potential to cause temporary and localised redistribution of flood flows which may have impacts on other nearby infrastructure, including structures and floodplain harvesting works. However, the earthworks required for a typical transmission tower would typically be minor and is therefore not expected to have a substantial potential influence on flood flows and levels at any one individual tower location. Any influence would be limited to location in the immediate vicinity of each tower. The construction planning would consider how these temporary changes would be managed to prevent significant impacts occurring.

Large stockpiles (if required) in flood prone areas may result in changes to flood behaviour beyond the construction impact area as it could reduce floodplain storage, redistribute and redirect floodwaters, and subsequently impact other land and infrastructure, including floodplain harvesting works. Construction planning would consider how these temporary changes would be managed to prevent significant impacts occurring. Locating stockpiles outside of flood prone areas or areas prone to deep and fast flowing floodwaters would assist in minimising impacts on flood flows.

The site for the proposed Dinawan 330kV substation and upgrade and expansion of the Wagga Wagga substation are not affected by flooding and subsequently there would be no flooding impact of construction works at the site.

All other construction compounds and accommodation facilities are located away from flood prone areas and therefore would have no impact on flood behaviour.

Section 4.4.1 identified existing flood affected roads. The flood affectation of these roads is unlikely to change due to the proposal construction activities because there would be no significant change to flood behaviour in the adjacent floodplain which affects flooding at these roads.

5.2 Geomorphology

The major waterway crossings as part of the proposal would include the Murrumbidgee River at Balranald; Abercrombie Creek; Yanco Creek; the Coleambally Outfall Drain, Colombo Creek; Hallidays Cut (at Lake Cullivel); Burkes Creek (The Rock) and several other smaller creek crossings. Transmission line towers would be constructed at least 50 metres from the edge of the major waterways but are unlikely to be able to avoid the riparian areas of all first and second order streams.

There would be no permanent access track crossings of the major waterways crossed by the proposal. However, there would be numerous crossings of minor streams and the potential impacts to geomorphic conditions of these waterways would include:

- changes in low flow channel shape due to temporary works changing local runoff behaviour
- increased sediment load from runoff from construction areas.

The final siting of towers would be such that there would be no transmission towers located on or in waterways banks and so no direct geomorphological impacts would be anticipated from construction work. Transmission line towers located within the flood plain may contribute to the above geomorphological impacts during flood events as a result of changes to overland flow paths. These impacts would be minor but could result in changes erosion and to channel shape due to the high fragility and lower recovery potential of minor waterways. Where transmission line towers are located out of the flood prone area, there would not be any geomorphological impacts.

5.3 Water supply, water resources and wastewater

Water would be required during construction for:

- dust suppression on substation construction sites and line tower construction sites, and on access tracks through the use of a water spray attached to a tanker vehicle (including the possible use of water reduction polymers)
- concrete batching activities for use when mixing with cement, aggregates and water for transmission line towers and substation foundations
- wetting backfill material (if it is too dry for effective compaction)
- general worker facilities at the main construction compound and camp sites.

It is estimated that about 1.1 gigalitres of water would be required for construction, comprising:

- 728 megalitres for dust suppression
- 203 megalitres for earthworks compaction
- 20 megalitres for concrete batching activities (potable water)
- 11 megalitres for vehicle washdown facilities
- 100 megalitres for camp sites (potable water).

Water would be supplied for the proposal from existing regulated sources. Water would be purchased from the existing water market within the region or from local council facilities. Access to these sources would occur through the use of existing, licensed water extraction infrastructure only. No new points of water extraction are proposed. Transgrid would rely on existing water access licences for these points.

Transgrid has commenced discussions with a number of water suppliers within the broad region through which the proposal would be located to identify the required volume water (potable and non-potable) for the proposal from existing facilities. This has included initial consultation with local councils, Riverina Water and other water suppliers such as the Coleambally Irrigation and private water licence holders. Based on initial consultation, 26 potential sources of water have been identified along the length of the proposal which have the potential to support the construction water needs for the proposal. Further details of the proposed water supply strategy for the proposal is provided in Section 6.9.2 of the EIS.

Wastewater would be generated from staff facilities and construction activities. The major impact from release of wastewater would be elevated nutrient levels. Wastewater treatment facilities would be constructed at each of the four newly proposed accommodation camp sites (Cobb Highway, Dinawan and Lockhart, noting the previously approved Buronga accommodation camp would include a wastewater treatment facility). The systems would be designed to collect wastewater from showers, kitchens, laundries and toilets, with toilet and kitchen facilities located both at the camp and the office areas and designed to proposed personnel numbers at each accommodation camp site. The wastewater would be treated to a suitable standard to facilitate appropriate reuse (for example for construction purposes and dust suppression) in a manner that does not pose a soil or water contamination risk. The waste stream from the wastewater treatment processes would be collected and transported to a relevant council wastewater treatment plant (or other approved/licensed facility).

Wastewater produced during the initial establishment of the proposed accommodation camps would be collected and transported to a relevant council wastewater treatment plant (or other approved/licenced facility). This process would be in place during the site establishment works and would cease once the wastewater treatment facilities become operational.

The proposed wastewater treatment plants would be a generally contained system and would include biological and chemical treatment, filtration and disinfection. At site locations outside accommodation camp sites, wastewater facilities would continue to be installed to provide amenity to workers at these locations. Liquid waste would be removed and transported to a licenced facility.

The volume of water to be treated would be dependent on the camp and office occupancies and associated water use at any one time throughout the construction period. A conservative allowance of up to 240 litres per person, per day has been allowed for (consistent with the allowance made for the EnergyConnect (NSW – Western Section)). At peak, each accommodation camp would therefore see a potential daily throughput for treatment of between 84,000 litres for a smaller camp such as Lockhart up to around 120,0000 litres for a larger camp such as the proposed Dinawan 330kV substation accommodation camp (when at maximum capacity).

The wastewater treatment facilities would be designed to produce effluent that meets the requirement for dust suppression and other construction related activities. The treated wastewater quality would be treated to comply with ANZECC and ARMCANZ (2000) guidelines for irrigation water and subject to disinfection prior to use. Wastewater discharges to watercourses would not occur.

5.4 Water quality

The construction of the proposal has the potential to further degrade the water quality of the waterways within the hydrology and flooding study area and areas downstream of this area, if not properly managed. The construction activities assessed with regard to water quality impacts included but are not limited to:

- vegetation clearing
- soil stripping, transportation and stockpiling for all construction, laydown, staging areas and access tracks
- earthworks and establishment of construction pads for each transmission line tower and for the proposed Dinawan 330kV substation
- construction of footings and foundation works for the new transmission line towers including boring and/or excavation, steel fabrication works and concrete pours
- establishment and operation of concrete batching plant(s) during construction
- establishment and construction works within the brake/winch sites
- potential for local waterway crossings and causeways at small waterways where alternative access routes are impractical

- use of heavy and light machinery such as scrapers, excavators, dumpers, rollers, chainsaws and other equipment for all above activities (resulting potential spills or leaks of chemicals fuels or other waste materials)
- establishment and operation construction compounds and accommodation camps along the proposal, including water access points.

Based on these activities, construction of the proposal may lead to increases of the following pollutants into waterways:

- nutrients (nitrogen and phosphorus) – commonly present in agricultural areas that may become mobilised from disturbance of agricultural land for construction work
- sediment from vegetation and top soil clearing, soil excavation, movement and storage and stormwater runoff through disturbed sites
- chemicals, fuels and hydrocarbons from use, refuelling and maintenance of equipment and construction machinery
- concrete slurry and wastewater – from mobile concrete batching plants
- contaminants of concern related to previous land uses – heavy metals, Total recoverable hydrocarbons (TRH), Benzene, Toluene, Ethylbenzene, and Xylenes (BTEX), Polycyclic aromatic hydrocarbon (PAH), organochlorine pesticides (OCP) and organophosphorus pesticides (OPP)
- heavy metals such as zinc, lead, copper, nickel, cadmium and chromium from disturbance of contamination and use and maintenance of vehicles and plants
- problem soils such as saline and acid sulfate soils
- gross pollutants such as paper and plastic packaging and materials from material use on construction sites and general construction staff litter.

The construction of the proposal may further degrade water quality if not properly managed but it is assumed that water brought to the site would be free of contaminants and fit for use. Poor management of locally generated surface water may subsequentially have impacts to surrounding ecology, sensitive receivers and other water uses. The likelihood and magnitude of risks would vary depending on the stage of construction, the area of disturbance and presence of high rainfall or wind weather events. A Construction Environmental Management Plan (CEMP) and associated Soil and Water Management Plan (SWMP) would be prepared prior to construction of the proposal. The SWMP would identify the measures required to be implemented at construction work sites and this would limit the impact of the proposal (refer to Chapter 23 of the EIS for details). These would include soil and water measures which are commonly applied and well understood and are which are discussed in further detail in Chapter 8.

Potential construction water quality impacts associated with each of the key construction activities are discussed below.

5.4.1 Vegetation clearing

In general, all tall growing vegetation and hazard trees within the transmission line easement that may intrude on the operation of transmission line would be removed (refer to Section 5.4 of the EIS for details). Vegetation would be removed within 20 metres of each tower as part of the permanent footprint. Some vegetation removal may also be required for temporary access and construction laydown sites This vegetation would be removed using chainsaws and also by earthmoving equipment such as bulldozers being used above ground level.

Removal of vegetation increases risk of soils run-off and displacement. Removal of scrub and undergrowth would be minimised where possible.

5.4.2 Earthworks

Earthworks would be required for proposal elements such as construction of transmission line towers, construction of the proposed Dinawan 330kV substation, expansion of the Wagga Wagga substation and for all general civil works required for permanent and temporary roads, construction compound and accommodation camps, and other ancillary facilities. Substantial earthworks would be carried out at the Dinawan 330kV substation including a proposed earthwork material site up to 200,000 cubic metres and use of this material to create a new pad for the substation.

Excavation works at each transmission line site would be required for the installation of foundations, levelling around the tower foundations and drainage and grading or preparation for construction at the tower site. The disturbance area at each transmission line tower for assembly would be about 60 metres by 90 metres and up to 16 metres deep (for piling of tower pads at the potential deepest locations). Bench structure sites may be required to provide a level platform for construction activities and would be constructed by use of earthing equipment such as graders and excavators.

Tower foundations would either be bored piles, driven steel or concrete piles, reinforced concrete pad footings and/or steel screw piles. The transmission line towers would either be guyed or free-standing towers. The construction methodology would be similar for either but the foundation footprints would be slightly different in size. Piling rigs would also be used to bore or drive piles for tower bases. Materials including batched concrete would be delivered by the nominated road/access tracks.

Earthworks would increase the amount of disturbed and exposed soil available, which may impact the surface water quality of the environment through:

- changes to surface water run-off or evaporation due to clearing vegetation coverage. This may increase run-off volumes at both the temporary or long-term time scale
- increased surface water run-off due to soil stabilisation earthworks. Soil stabilisation may result in change to the permeability of the natural soils
- mobilisation of saline soils that may affect salinity levels and potentially damage concrete and metal structures
- mobilisation of contaminants or heavy metals that are present in soils
- increased turbidity, lowered dissolved oxygen levels and increased nutrients in water ways
- potential impacts to groundwater quality where there is interaction between the surface and groundwater (refer to Section 4.11)
- reduction in channel habitat from sediment transport and deposition.

These risks would be ongoing throughout the life of the construction phase and would be highest at locations with a slope of greater than 2.5 percent, that are near waterways and that are frequently disturbed. Risks of sediment transport and erosion would also increase during high rainfall and wind weather events.

These potential impacts would be accounted for in the CEMP and SWMP. These would include requirements for progressive erosion and sediment control measures and on site management protocols. Spoil from the excavations associated with the transmission line may be reused on site wherever possible, however in some instances spoil would be removed from site and disposed of at a facility authorised to accept such waste. Any such on site re-use would be within the disturbance area and would not substantially alter landform or drainage in the vicinity of the transmission line towers.

Implementation of appropriate soil and water construction management measures would be anticipated to minimise impacts to water quality impacts from construction of the proposal. Additionally, impacts would be limited to the duration of construction and would be a short term. As such construction of the proposal would not cause significant changes to the water quality environment.

5.4.3 Construction compounds and accommodation camps

A series of construction compound and accommodation camp sites would be required during the construction of the new transmission lines to provide staging/laydown, concrete batching facilities and workforce accommodation for between 100 and 400 workers. These would generally comprise a camp alongside a laydown area occupying typically 300 metres by up to 500 metres. The following camp and laydown sites are proposed as part of the proposal:

- Buronga construction compound and accommodation camp – (assessed as part of the EnergyConnect – Western Section project and is not assessed further)
- Balranald construction compound, located off Yanga Way, with accommodation to be housed within and existing accommodation camp in Balranald
- Cobb Highway construction compound and accommodation camp

- Dinawan construction compound and accommodation camp within the area to the north of the proposed alignment, adjacent to Kidman Way
- Lockhart construction compound and accommodation camp (note two camp location options are currently being considered for this site with one to the north of township of Lockhart and one to the west of the alignment west of Brookong State Forest)
- Wagga Wagga construction compound, to east of the Wagga Wagga substation with accommodation to be housed within Wagga Wagga.

Establishment of these sites would include site clearing and additional impervious areas which may lead to increased run off and therefore increased sediment transport and erosion. There may be additional risks to water quality from release of gross pollutants and site litter from general site activities. A SWMP would be prepared for each site outlining management measures to manage and mitigate release of additional sediments, litter and pollutants during use of these sites.

The Buronga camp is not proposed to be amended as part works for the EnergyConnect East. The camp would be used to accommodate workers for the works for EnergyConnect (NSW – Eastern Section), however the assessment of the impacts for this camp were undertaken in the EnergyConnect (NSW – Western Section) EIS (WSP, 2020).

5.4.4 Waterway crossings

The proposed transmission line would cross a series of major watercourse including the Murrumbidgee River at Balranald, Abercrombie Creek, Yanco Creek, the Coleambally Outfall Drain, Colombo Creek, Hallidays Cut (at Lake Cullivel), Burkes Creek (The Rock) and several other smaller creek crossings.

Generally, the design of the transmission line would include a transmission line tower on either side of each major river crossing. A drone would be used to take a lead wire over the river or, in some cases alternative methods, such as the use of watercraft, may be used. It is not envisaged that any access tracks or bridges would be required for these particular crossings due to the design and proposed construction method of the transmission line at these locations.

Where alternative access routes are impractical, a number of local waterway crossings and causeways would be required at other smaller waterway locations along the length of the proposal. Where required, bed-level fords (i.e. construction of a good footing where a river or stream may be crossed) or causeways may be required to be constructed to provide temporary access. Where these crossings are required, they would typically be constructed using the following typical methodology:

- removing all loose material from the watercourse at the point to be crossed, forming a depression with firm base and sides
- the depression would then be filled with graded layers of rock. The rock layers would be placed so as to produce an interlocked bed of rock, sloped and dished, to allow water to drain freely through and flow over the causeway (minimum thickness of around 450 millimetres but not higher than the bed of the watercourse).

All watercourse crossing would be designed and installed in accordance with relevant Department of Primary Industries (DPI) guidelines for waterway crossings including:

- *Policy and Guidelines for Fish Friendly Waterway Crossings* (DPI, 2004a)
- *Why do fish need to cross the road? Fish Passage Requirements for Waterway Crossings* (DPI, 2004b)
- *Water Guidelines for Controlled Activities on Waterfront Land* (DPI, 2012a).

If required as part of a water crossing, culverts may also be installed in accordance with required standards (such as AS/NZS 4058 Precast concrete pipes (pressure and non-pressure)).

With the correct implementation of pre-construction and construction measures, there would be limited residual risk to waterways as a result of any waterway crossings used during construction of the proposal.

5.4.5 Stockpiling and spoil handling

The construction of the proposal would generate spoil, vegetation waste and general construction and demolition waste that would be stored in stockpiles. Excavated material would be stockpiled to be used for backfill around the tower foundations and embankment filling at the tower site from which it was excavated. Top soil would be kept separate from the excavated material to ensure placement at ground level during backfilling. Any excess excavated material would be spread evenly around the site after completion of the foundation backfilling (if suitable) or removed from the site and disposed of in accordance with the appropriate waste classification. There would also be screening of materials carried at the borrow pit at the Dinawan 330kV substation to create a pad for the substation.

Stockpiling and screening of earthwork materials would pose a risk to the existing water quality in receiving environments through the increased likelihood of movement of sediment. Stockpiling of mulched vegetation from clearing of trees and shrubs would also pose a risk of tannins leaching into watercourses, and increased loads of organics in watercourses. The discharge of water that is high in tannins may increase the biological oxygen demand of the receiving environment, which may in turn result in a decrease in available dissolved oxygen. Once discharged to the environment, tannins may also reduce visibility and light penetration, and change the pH of receiving waters. These impacts may affect aquatic ecosystems in receiving environments.

This material would be minimised and reused where practicable. Excess spoil stockpiled in locations that are open to rainfall or runoff would include appropriate management measures such as sediment fences and diversion drains to mitigate the impact of sediment movement offsite. Correct implementation of stockpile management protocols would mitigate and mange impacts to the receiving environments water quality.

5.4.6 Potential for spills and litter

The following activities have the potential to result in release of contaminants, oils, fuels, grease, chemicals and gross pollutants into the waterways in and surrounding the proposal:

- machinery and equipment operation, refuelling, maintenance and wash down
- spills and failure of machinery
- concrete batching, treatment and curing
- disturbance of contaminated soils
- inadequate management of chemicals, spoil, material stockpiles and litter from construction sites
- wastewater generated during construction.

Pollutants from these activities may be picked up in runoff from the site and enter the waterways and be transported downstream of the final proposal impact footprint. Water quality and ecological impacts may result from release of these contaminants into the catchment.

Temporary concrete batch plants would be constructed at the construction compounds and in some instances, in isolated locations that are greater than one hour from an existing regional concrete batching plant.

Mitigation and management measures such as bunding, silt fences and other physical measures, would be implemented as part of the construction of the proposal. This would reduce the potential for release of chemicals from construction sites and into waterways.

5.4.7 Summary of water quality impacts

The key water quality objectives for the proposal, based on the Basin Plan 2012, is to appropriately manage water quality, including salinity, for environmental, social, cultural, and economic activity and therefore protect downstream environments from the potential impacts of surface runoff and discharge during construction and operation. The detailed water quality objectives for the proposal are defined in Section 2.4. It is anticipated that through correct implementation of the standard mitigation measures during construction as described in Chapter 8 that there would be minimal impacts to the existing water quality condition of the hydrology and flooding study area. As such construction of the proposal would not cause significant changes to the water quality environment against the identified water quality objectives.

Where there are sensitive receivers located along the proposal, such as the Murrumbidgee River, water quality impacts from the construction of the proposal are anticipated to be short-term and limited in extent. Additionally, the progressive nature of construction would limit the work areas and duration within which impacts may occur. A water quality monitoring program would be developed to collect baseline data to characterise the existing water quality condition. The program would include water quality targets in line with the Basin Plan 2012, relevant water resource plan and the ANZG guidelines. Monitoring as part of this program would assist in identifying any issues arising as part of the construction of the proposal and therefore minimising impacts to water quality as a result of the proposal.

6 Assessment of operational impacts

6.1 Flooding

The proposals operational features would consist of transmission line towers in the floodplain and the supported transmission line. The towers would be spaced on average around every 450 metres (potentially up to 600 metres) with a footing area of between 53-metres by 53 -metres (300kV) and 64- metres by 64-metres (500kV) and the transmission line tower above. The transmission line tower above the footing would typically consist of largely open space with connections to the footing. The footing connections at the base of each transmission tower would therefore be the only component of the tower within the floodplain. The footings would not significantly reduce floodplain storage or impede flow. It is therefore estimated that there would be insignificant impacts to existing flood behaviours such that there would be no insignificant impacts to flood levels, flood depths, flood velocities or existing flood storage as a result of the towers and footings (where they are located in identified flood areas). Any changes in flood behaviour would be localised in the vicinity of each tower, and the design of each tower would be such that any changes would not affect their structural integrity.

Historic data for Lake Cullivel as presented in Section 4.4.1 indicates that the proposal would lie within land that is subject to flooding. In the vicinity of Lake Cullivel, between 6–10 towers will be located in the flooded area with their footings covering an area of a similar extent to the man made dams identified in the Figure 10. Given the wide flat nature of the floodplain in the vicinity of Lake Cullivel the impact of the towers on flood behaviour would be insignificant, but there may be minor local increases in flood levels and velocities that would dissipate within 50 metres of the tower footing. There is no flood sensitive development or infrastructure in close proximity to the towers at this location.

Permanent access tracks and optical repeater structures (where proposed) are not expected to impact flood behaviour, where they are located away from overland flow paths and will have minimal impact to overland flow paths as they will be designed to mimic the undulating nature of the existing surface. Permanent watercourse crossings are not proposed at the key watercourses along the proposal.

The proposed Dinawan 330kV substation and upgrade and expansion of the existing Wagga Wagga substation are not located within flood prone land and are therefore no impacts to or from flooding are anticipated. The site drainage at the proposed Dinawan 330kV substation would be designed to divert runoff to natural watercourses using appropriate dispersion structures or drainage systems and be designed to match on site overland flow conditions. The substation stormwater drainage system would be designed for a rainfall corresponding to a 10-year average recurrence interval. Runoff within the substation would be intercepted by roadside kerb and guttering, V drains and subsoil drains, and all associated pits and pipes, as appropriate. Runoff from outside the substation would be intercepted and diverted around the substation by catch or table drains and concrete boundary drains. The drains would be designed for rainfall corresponding to a 50-year average recurrence interval.

Once site hydraulics are understood based on final surveys and geotechnical investigations, the final design of the Dinawan 330kV substation would also incorporate the remaining landform of the earthworks material site as part of the permanent landform for the site. The earthworks material site is anticipated to remain unfilled (up to a depth of between one and two metres at the deepest point, subject to final earthwork requirements) of for the purpose of future stock dams (or other use) to be agreed with the property owner.

The impact to flood levels from the proposal would only be localised and would not affect the large flood extents experienced on around the waterways across the proposal. The proposal is not predicted to have an impact on the flood affectation of structures (including buildings) and infrastructure (including roads) located near the proposal. As such there is not expected to be any change to use of the roads during a flood emergency or existing flood emergency management arrangements as outlined in the relevant Local Flood Plans.

6.2 Geomorphology

Potential impacts to geomorphology would include:

- changes in low flow channel shape due to placement of towers in low flow points which changes low flow runoff behaviour
- increased sediment load from runoff from permanent access tracks.

Transmission line towers located within the flood prone area of the waterways may have minor, localised geomorphological impacts to the existing waterways during flood events. The placement of the towers may be within minor low flow paths (1st and 2nd order streams) which would then result in changes in the position of these flow paths and movement of sediment locally within the flow path. However, this would not affect the main watercourse channels and regular flow regimes within the channels. Additionally no transmission towers would be located within the banks of waterways with a stream order of 7 and above and therefore no geomorphological changes within the waterways are expected that would affect the long term health of the waterway (being the movement of sediment (including nutrients) and the presence of ponds or ripples that support aquatic fauna and flora).

Localised changes within flow paths may be experienced for the regular flood events but no significant impact is expected in large flood events, such as the 1% AEP. Where transmission line towers are located out of these minor waterways, there would not be any geomorphological impacts.

6.3 Water supply and water resources

Water would be required during operation for maintenance activities and the operation of the Dinawan and Wagga Wagga substations. This is expected to result in an additional typical 12,000 litres of water per year compared to the existing requirements and would be sourced from the local water authority and rainwater tanks at the substation.

When in operation the substations would require minimal water. Water would only be needed for toilets and hand basins in the control room, and potable water for any other amenity requirements. Testing of the fire system may require some water, but this would likely be done on a yearly basis and would use tank water stored on site.

The long term impacts of this water use would be minor but potentially be affected during dry periods where water availability and rain water tanks may be low, and competition for water resources from existing irrigation suppliers may be increased.

6.4 Water quality

There is potential for water quality impacts as a result of spills or litter generated from operation and maintenance activities along the transmission lines and at transmission line towers near waterways, however, these impacts would be minor and localised. Provided correct operation procedures and safeguards are implemented the residual likelihood of impacts would be very low. There would not be any impacts to water quality expected as a result of the presence of the transmission lines in the landscape.

There is potential for operational water quality impacts from any the new impervious area at the proposed Dinawan 330kV substation. The new impervious areas have the potential to cause increased run off volumes and speeds, with potential for increased scour and sediment loads. The drainage system at the substation would collect and discharge surface and subsoil water to appropriate containment structures. Runoff within the switchyard would be intercepted by roadside kerb and guttering, V-drains and subsoil drains, and all associated pits and pipes, as appropriate would be diverted to natural waterway using appropriate dispersion structures or drainage infrastructure. Runoff outside the switchyard would be captured and diverted to natural waterways using appropriate dispersion structures or drainage infrastructure. This would minimise potential scour and sediment movement from additional runoff from the new impervious areas introduced as part of the substation.

The drainage system would also separately drain oil and oil contaminated water to the appropriate containment structures. The oil containment system would be provided in accordance with Transgrid's procedure GD AS G2 101 – Substation Oil Containment Design Principles, which defines Transgrid's approach to meeting the requirements of the Protection of Environment Operations Act and would therefore minimise the potential for water quality impacts from oils.

There may be additional impervious area added as a result of the expansion of the Wagga Wagga substation, however this is expected to be minor and new stormwater drainage would be installed as required to connect with the existing drainage system within the Wagga Wagga substation. There would therefore be no impacts to water quality downstream of the substation.

Water quality impacts as a result of the operation of the proposal in all other locations would be negligible. As such operation of the proposal would not cause significant changes to the water quality environment against the identified water quality objectives.

7 Cumulative impacts

Cumulative impact assessment means the consideration of other nearby development projects along with the proposal. Projects with the potential for cumulative impacts with the proposal were identified through a review of publicly available information and environmental impact assessments from the following databases:

- NSW Major Projects website (NSW Government, searched October 2020)
- Wagga Wagga, Narrandera, Edward River, Murray River, Balranald, Hay council websites (searched October 2021)
- Australian Government – Department of Environment and Energy, EPBC Public notices list (Australian Government, searched October 2020).

A number of proposed developments have been identified and these include:

- EnergyConnect – Western Section
- Buronga Solar Farm
- Buronga Landfill Expansion
- Buronga – Gol Gol residential expansion
- Inland Rail – Albury to Illabo
- Uranquinty Solar Farm
- Gregadoo Solar Farm.

7.1 EnergyConnect (NSW – Western Section)

The EnergyConnect (NSW – Western Section would comprise around 135 kilometres of new 330kV double circuit transmission line and associated infrastructure between the SA/NSW border and the existing Buronga substation, upgrade of the Buronga substation and upgrade of the existing 22 kilometre 220kV single circuit transmission line between the Buronga substation and the NSW/Victoria border at Monak. Transgrid has previously sough, and received, separate environmental planning approvals for the EnergyConnect (NSW – Western Section.

The EnergyConnect (NSW – Western Section) was approved in September 2021. Construction of the proposal is scheduled to commence in early-2022 (enabling phase). The construction of the transmission lines would take about 18 months while the Buronga substation upgrade and expansion would be delivered in two components and be operational by mid-2023.

As assessed in the EnergyConnect (NSW – Western Section) *Hydrology and Flooding Impact Assessment* (WSP, 2020) there would be minimal impact from the construction and operation of this project provided correct implementation of soil and water management plans. As such it is estimated that there would be no cumulative impacts to geomorphology, water supply or water quality as a result of this project and the proposal.

7.2 Buronga Solar Farm

The Buronga Solar Farm development includes a 400 MW solar farm with energy storage and associated infrastructure located adjacent to the proposal Buronga substation. The EIS for the project is currently being prepared. The project would also involve the construction of a 220kV or 330kV transmission line for connection to the existing Buronga substation. The construction schedule for the proposal is identified as being about 18 to 24 months from site establishment to completion (noting commencement subject to approval from DPIE).

With appropriate soil and water control measures in place for both developments during construction and operation it is estimated that there would be no cumulative impacts to geomorphology, water supply or water quality as a result of this project and the proposal. The site is located out of the floodplain and therefore would not impact local flood risk.

7.3 Buronga landfill expansion

The proposal includes the expansion to the existing Buronga landfill to allow for an increase in the total quantity of waste that can be accommodated from 30,000 tonnes to 100,000 tonnes of general waste per annum. The proposal would consist of the construction of multiple additional landfill cells over the next 30 years comprising a volume of about 4.8 million cubic metres over an area of about 395,000 square metres (including the current active landfill cell).

The project is at currently passing through the assessment and approval stage to identify key environmental risks as a result of the project. Given this is an existing operational landfill site, it is anticipated that additional impacts to hydrology and water quality would be managed in line with existing procedures during construction and operation. As such it is estimated that there would be no cumulative impacts to geomorphology, water supply or water quality as a result of this project and the proposal. The site is not located in the floodplain and therefore would not impact local flood risk.

7.4 Buronga – Gol Gol residential expansion

Wentworth Shire Council is proposing new subdivisions to provide about 500 new large residential housing allotments in the Buronga – Gol Gol growth area, about 10 kilometres to the west of the hydrology and flooding study area

It is not expected that there would be cumulative impacts to flood risk and geomorphology because the development will need to comply with the Wentworth Shire Council Development Control Plan 2011 which outlines conditions for erosion and sediment control and flood liable land.

No timeframe on proposed development of the urban release areas has been identified at this time, however should the proposed residential expansion commence at the same time as the construction of the proposal, this may result in a cumulative demand for water during the construction phase. Long term water supplies may be impacted if water demand management strategies are not developed. The change in land use is also likely to impact local water quality.

7.5 Inland Rail – Albury to Illabo

ARTC is proposing to upgrade the Albury to Illabo section, along the 185 kilometres of existing operational narrow-gauge railway from the Victorian/New South Wales border to Illabo in regional NSW. The Proposal would provide clearance of the existing 'Main South' corridor to operate 1,800 metres long, 6.5 metres high, double stacked trains and includes the provision of dual track in areas for train passing. The project is made up of discrete sections of proposed upgrade, including upgrades within the existing rail corridor at Uranquinty, The Rock and within the centre of Wagga Wagga.

Subject to planning approval, construction is planned to commence in mid-2023 and complete by late 2024. Operations to commence in 2025.

The proposal impacts to flooding, geomorphology, water supply or water quality during construction and operational phases are expected to minimal. The Inland Rail project disturbance area would be contained generally to the existing rail corridor, and therefore cumulative impacts are not expected with the proposal not be expected.

7.6 Uranquinty Solar Farm

Origin Energy is proposing to develop a commercial scale solar photovoltaic site and associated battery storage at Uranquinty. The proposal would have a capacity of up to 200 megawatts (MW) of renewable energy production for the local electricity supply. The site is located north-west of Uranquinty village along Uranquinty Cross Road, around 15 kilometres south-west of Wagga Wagga. Given current timing for the proposed solar farm, there is the potential for the proposal and the solar farm construction periods to overlap.

With appropriate soil and water control measures in place for the development during construction and operation it is estimated that there would be no cumulative impacts to geomorphology, water supply or water quality as a result of this project and the proposal. The site is not located in the floodplain and therefore would not impact local flood risk.

7.7 Gregadoo Solar Farm

The Gregadoo Solar Farm will be located about 13 km south-east of Wagga Wagga. The project is proposed to comprise construction, operation and decommissioning of a maximum 47 MW solar farm and associated infrastructure. Construction is expected to commence mid-2021.

With appropriate soil and water control measures in place for the development during construction and operation it is estimated that there would be no cumulative impacts to geomorphology, water supply or water quality as a result of this project and the proposal. The site is not located in the floodplain and therefore will not impact local flood risk. An assessment of the potential flood hazards for this project in the EIS (NGH Environmental, 2018) identified that the development would be unlikely to adversely impact flooding behaviour and would not increase flood affectation at other property and infrastructure sites.

7.8 Summary

With appropriate water quality measures in place and the proposed development being located outside of the floodplain no substantial cumulative impacts would be expected during construction and operation. The demand for water for this proposal, the solar farms, landfill expansion, Inland Rail and the residential expansion would cumulatively put pressure on supply sources particularly during the construction phase of each proposal and potentially during the operational phases. Consultation with relevant local councils would need to occur in relation to the proposal's water supply strategy to ensure there is effective management of these demands.

8 Mitigation measures

Chapter 5 and 6 identified a range of impacts as a result of the proposal during construction and operation. The identified impacts associated with the proposal are largely related to potential impacts on existing water quality. The following sections provide proposed mitigation measures which would be implemented for the proposal to mitigate the identified impacts. Table 8-1 details the proposed mitigation measures the proposal.

Table 8-1 Mitigation measures – Surface water and hydrology

ID	IDENTIFIED MITIGATION MEASURE	TIMING	APPLICABLE LOCATION(S)
HF1	Permanent operational infrastructure and landforms within the transmission line easement would be designed and implemented/formed to minimise any potential scour and erosion risks associated with surface water runoff.	Pre-construction, construction	All locations
HF2	Detailed construction planning would consider flood risk at construction areas. This would include: — identifying of measures that would be implemented to not worsen flood impacts downstream and on other property and infrastructure during construction up to and including the five percent AEP design flood event — confirming site layouts to avoid or minimise obstruction of overland flow paths and to limit the extent of flow diversion required. Practicable measures identified to minimise potential flood risks at construction areas would be implemented.	Pre-construction, construction	Transmission line and construction sites within flood prone land
HF3	A water quality monitoring program would be implemented to establish baseline water quality conditions at perennial watercourses that the transmission lines would cross, and to facilitate monitoring of any changes in water quality that may be attributable to the proposal during construction. The frequency, location and duration of sampling would be detailed in the monitoring program, but would include: — at a minimum two monitoring locations (one located upstream and one downstream of the crossing transmission line crossing) of the proposal on Colombo Creek — downstream monitoring on the Murrumbidgee River with consideration of existing upstream WaterNSW gauges (including gauge 410130) — monitoring for total dissolved solids, total suspended solids, total nitrogen and total phosphorus. Sampling in the Murrumbidgee River and Colombo Creek would commence at least six months prior to the commencement of ground disturbing activities within the riparian zone at each respective location and then monthly during construction until completion of rehabilitation works in the respective areas. If there are exceedances of water quality criteria, then measures adopted as part of HF5 would be reviewed and revised. Monitoring would continue monthly during construction at each respective location until completion of rehabilitation works in the respective areas	Pre-construction and construction	Murrumbidgee River, Colombo Creek, Irrigation channel near Dinawan 330kV substation site (between Coleambally Irrigation Area and Yanco Creek)

ID	IDENTIFIED MITIGATION MEASURE	TIMING	APPLICABLE LOCATION(S)
HF4	Water supply options and management would be undertaken in accordance with agreements between the construction contractor and relevant suppliers.	Construction	All locations
HF5	A Soil and Water CEMP sub-plan would be developed and implemented in consultation with a Certified Professional in Erosion and Sediment Control during construction. The plan would detail the processes, responsibilities and measures to manage potential soil and water quality impacts in accordance with the principles and requirements in: — *Managing Urban Stormwater – Soils and Construction, Volume 1* (Landcom 2004), and *Volumes 2A and 2C* (NSW Department of Environment, Climate Change and Water 2008), commonly referred to as the 'Blue Book' — *Best Practice Erosion and Sediment Control* (IESCA – 2008) — Transgrid's Environmental Guidance Notes — Guidelines for Controlled Activities on Waterfront Land (NRA 2018). The Soil and Water CEMP Sub-plan would contain appropriate measures (as a minimum) to: — minimise the extent of ground disturbance — divert surface water runoff around construction locations — install erosion controls within construction locations — collect and filter sediment from surface water runoff within construction locations — manage stockpiles to minimise erosion and sediment transport — manage saline and acid sulfate soils (if present) — minimise the potential of soil and water quality impacts during storage of project wastes and potentially polluting substances — minimise the duration of soil exposure and progressively rehabilitate and stabilised disturbed areas — manage unexpected finds of contaminated materials — manage spills to reduce and address soil and water contamination.	Construction	All locations
HF6	Maintenance works in the vicinity of waterways would be conducted in accordance with Transgrid's Environmental Guidance Notes.	Operation	Transmission lines

It is anticipated that implementation of appropriate soil and water construction management measures as discussed above would mitigate and minimise the potential flooding and water quality. As such construction and operation of the proposal is not anticipated to cause significant changes to the existing flooding or water quality environment against the *Basin Plan 2012* water quality objectives (refer to Section 2.4).

9 Conclusion

This report documents the hydrologic and flooding assessment that has been carried out for the proposal. This assessment has been used to inform construction planning, operation and environmental assessment of the eastern section of EnergyConnect.

Impacts to flood behaviour during construction would be associated with works for the transmission line towers that are located within the flood extent around major waterways. The impacts of the proposal to flooding during construction are likely to be temporary, localised and minor. Earthworks and construction have the potential to divert overland flows and/or displace floodwaters and worsen flood conditions in adjacent land. Ongoing refinement of construction planning for the proposal would need to consider flood risk at construction areas including identification of measures to not worsen flood impacts downstream and on other property and infrastructure during construction up to and including the five percent AEP flood event (or similar appropriate level of event). This would also include consideration of specific site layouts and staging of construction works to avoid or minimise obstruction of overland flow paths and to limit the extent of flow diversion required. Consequentially impacts to drainage/flood during construction are anticipated to be minimal. All other facilities (such as the proposed Dinawan 330kV substation and the upgrade and expansion of the Wagga Wagga substation), would be located away from flood prone areas and therefore would have no change in impact to existing flood behaviour. Consideration would also be given to avoiding temporary works within overland flow paths in these areas so as not to worse flooding in adjacent areas of known flooding.

Both the construction and operation phases of the proposal have the potential to impact on the water quality of the surrounding environment. Potential impacts from the construction phase would largely be associated with the potential for increased erosion, sediment loads and release of contaminants to the receiving waterways from construction activities such as vegetation clearing, soil excavation, stockpiling and construction of transmission line towers.

Impacts to water quality would be more likely to occur during rainfall events which cause runoff, particularly in construction areas that have been cleared, around stockpiles or where there are exposed soils. With regard to the water quality objectives laid out in the NSW WQO and Basin Plan 2012, the existing conditions of Murray and Murrumbidgee catchments indicate that the existing water quality of the watercourses in the hydrology and flooding study area are generally not compliant with the Basin Plan currently. Nevertheless, construction activities and operation of the proposal would need to manage water quality from the proposal to ensure the Basin Plan water quality objectives are met and do not result in further decrease in water quality from those currently identified as the existing conditions.
The implementation of the identified erosion and sediment control measures are expected to result in minimal impact to water quality outside of the hydrology and flooding study area.

During operation there may be small impacts to water quality from any changes to sedimentation and erosion regimes as a result of the transmission line towers located within overland flow paths, however these impacts are likely to be minor and infrequent. All other elements of the proposal (such as the proposed Dinawan 330kV substation and the upgrade and expansion of the Wagga Wagga substation) are located away from waterways and flow paths and as such would be unlikely to have any additional water quality impacts as a result of the operation of the proposal.

Mitigation and management measures (which would be documented in the CEMP for the proposal) have been identified for both construction and operation phases of the proposal. It is anticipated that correct implementation of these measures would mitigate and minimise the potential geomorphic and water quality impacts.

10 Limitations

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Appendix A

Preliminary flood risk assessments for the study area

EnergyConnect Flood Study - Phase 1– Stage 1

Desktop Assessment and Spatial Analysis

Prepared for TransGrid
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5 November 2019

Creative people together transforming our world

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Appendices

Appendix A – Spatial Analysis Results

Revision History

Revision Nº	Prepared By	Description	Date
1	Natasha Webb	Revision A	10/10/2019
2	Natasha Webb	Revision B	18/10/2019
3	Natasha Webb	Revision C	05/11/2019

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Natasha Webb**		05/11/2019
Reviewed by	**Luke McLean**		05/11/2019
Approved by	**Mark Jacob**		05/11/2019
on behalf of	Beca Pty Ltd		

1 Introduction

The following report outlines Stage 1 of the hydrological study of the proposed 330 kV EnergyConnect transmission line. Stage 1 consists of a desktop assessment and spatial analysis of the:

- Proposed 330 kV interconnector routes, provided in the following KMZ files from TransGrid:
  - 330kV-(Boarder- Buronga -Darlington Point -Wagga) & 220kV-Redcliffs (Rev2).kmz
  - Darlington South Route Option (PEC).kmz
- 2 km corridor (i.e. 1 km either side of the route centreline).
- Preliminary tower locations, provided in the following KMZ files:
  - Optimum Spotting - Buronga to Border.kmz
  - Optimum Spotting - Buronga to Red Cliffs.kmz
  - Optimum Spotting - Darlington Point to Buronga.kmz
  - Optimum Spotting - Wagga Wagga to Darlington Point.kmz
- Desktop access tracks, as outlined in:
  - Basis of Design and Cost Estimation – Access Tracks for Dry Weather Access Only Revision 3 (Beca Pty Ltd, August 2019).
- Attributing catchment and waterways.

This document outlines the methodology and results from Stage 1 – Desktop Assessment and Spatial Analysis.

DISCLAIMER:

Stage 1 Spatial Analysis is a topographical flow path analysis between the proposed route and stream order.

Stage 1 is **NOT** a flood study of the proposed alignments. This analysis does **NOT** provide flood levels, depths or hazard classes for the proposed alignments and tower locations. This information would be provided as the outcome of Stage 2 - Targeted 2D Tuflow HPC modelling.

This topographical flow path analysis:

- Identifies intersections between the proposed route/preliminary tower locations and waterways,
- Categorises the intersections to inform areas where the initial development route alignment and tower locations should be given greater attention caused by increased interaction with surface and flood water.

This analysis does **NOT** provide:

- Water levels, flood depths, flood velocities, or flood hazard classes along the alignments.
- Identify areas of historical flooding levels along the alignments.
- Identify areas along the stream and river orders subject to flood breakout, floodway flows or flood storage.
- Identify at any level of detail the irrigation systems within proximity to the towers locations and adjacent catchments, nor quantify their potential effect on flowpaths.
- Identify or consider major waterway or river control structures within the catchments.
- Identify the property title or property ownership of the corridor and tower locations.
- Frequency and severity information of storms for the catchment.
- Potential for debris loading along the identified waterways.
- Accuracy check on source data used in open source databases.
- Ground truthing.

The information produced in this report is for the sole purpose of the assessment of the proposed transmission line route for the EnergyConnect project. The information has been produced based upon the validity of the project data provided at the time of undertaking this analysis and is considered appropriate for this stage of the assessment. The information provided in these files are **NOT** be used for alternative purposes.

2 Project Description

2.1 Route Description

The proposed 330 kV transmission line route travels from Wagga Wagga to the South Australia New South Wales border. The route is divided into 3 route alignments (outlined in Table 2-1), with the route extents shown in Figure 2-1.

Preliminary tower locations have been placed at approximately 600 m intervals along the route, with desktop assess tracks defined for the work areas around towers.

Table 2-1 EnergyConnect Proposed Routes

Route	Description	Data Source (KMZ File)
Alignment 1	NSW/SA Border to Buronga	330kV-(Boarder- Buronga -Darlington Point - Wagga) & 220kV-Redcliffs (Rev2).kmz
	Red Cliffs to Buronga	
Alignment 2	Buronga to Darlington Point	330kV-(Boarder- Buronga -Darlington Point - Wagga) & 220kV-Redcliffs (Rev2).kmz
	Darlington Point to Wagga Wagga	
Alignment 3	Darlington South Route Option	Darlington South Route Option (PEC).kmz

2.2 Catchment Description

The proposed route traverses the Murray Darling Basin, as shown in Figure 2-1. This basin is the catchment for Australia's largest river system and covers over 1 million km^2. The basin is bounded by the Great Dividing Range. The north and west of the basin is flat and semi- arid, with the environment ranging from saltbush shrublands and mulga lands to farm land.

The Murray Darling Basin contains Australia's 3 longest rivers; the Darling/Barwon river system, the Murray River and the Murrumbidgee River. The proposed route intersects each of these river systems, with the Murrumbidgee River running along parallel to Alignment 2 and Alignment 3.

The Murrumbidgee River is the third longest river (approximately 1,500 km in Australia at approximate, whose catchment presents 8% of the Murray-Darling Basin (Murray-Darling Basin Authority, 2019) and is contains many wetland and riverine environments. This river starts in the Australian Alps and ends on the semi-arid riverine plains. It contributes to 16% of the Murray-Darling basin water (Murray-Darling Basin Authority, 2019). Historical accounts and records described numerous occasions of riverine flooding of Murrumbidgee that have caused flood damage, loss of property and disruption to services (Murray-Darling Basin Authority, 2019).

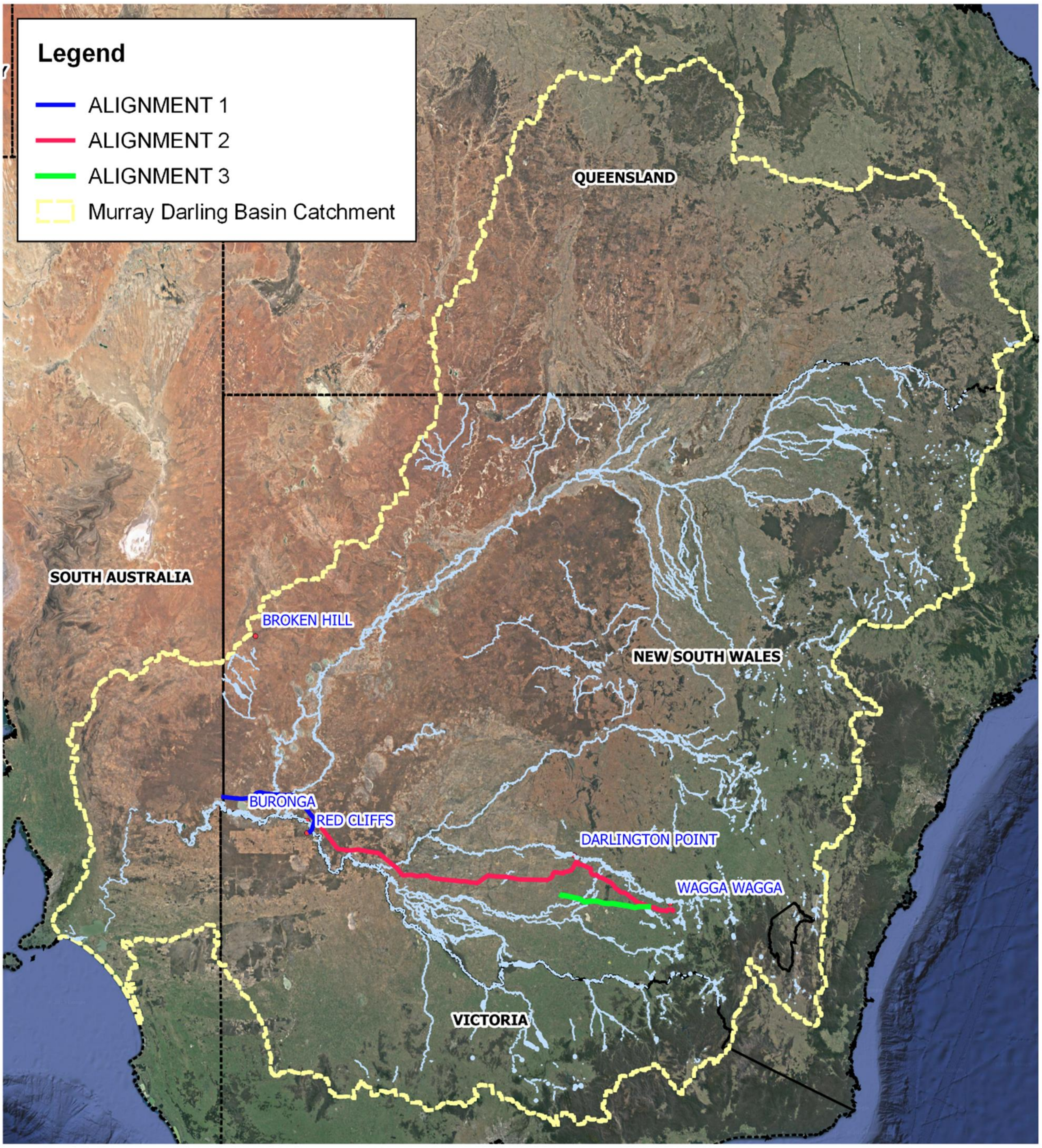


Figure 2-1 Energy Connect Proposed Route and Catchment Area (Murray Darling Basin)

3 Methodology

3.1 Desktop Assessment

The desktop assessment was undertaken to determine the data availability and suitability to progress to the spatial assessment, and to form part of the flood modelling for Stage 2. It consisted of data collation and a high-level gap analysis, utilising the rating system described in Table 4-1. This rating system was used to flag issues that may affect the uses and acceptability of the data/information.

3.2 Spatial Analysis

Based upon the data collated from the Desktop Assessment, a spatial analysis was undertaken for the Murray Darling Basin. The spatial analysis was performed on the NASA Shuttle Radar Topography Mission (SRTM) Hydro Enforced Lidar (2011, GeoScience Australia). The SRTM 1 sec Hydro Enforced Lidar provides coverage of the whole basin, with a resolution of 1 arc-sec (approximately 30-m grid).

The spatial analysis consisted of the following processes:

1. Watershed analysis for catchment delineation and stream line definition of the Murray Darling Basin to identify sub-catchments and waterways and tributaries.
2. Stream Order (Strahler) analysis of the stream lines defined from Watershed.
3. Conflict analysis of between the stream lines to identify the number of conflicts between the waterways with:
   - Preliminary Tower Locations;
   - Proposed route corridor; and
   - Desktop Access Tracks.
4. Categorisation of the conflict locations to identify locations/towers that would require further assessment of the alignment and require flood modelling. This categorisation was based upon the waterways stream order, as stream order is a relative measure of the size of streams. It can be used to infer characteristics of streams, i.e. the smallest tributaries (referred to as first-order streams) are dominated by overland flow, while a stream that is fifth-order or larger constitutes a river. The rating systems for conflict locations are further described below in Section 3.2.1.

The processes outlined above are repeatable to provide flexibility should updated and/or additional design data be provided.

3.2.1 Conflict Categorisation

Two rating systems have been developed for the categorisation of the conflict locations, based upon the preliminary tower locations, proposed route corridor and desktop assessment:

Rating System 1: Conflicts between waterways and preliminary tower locations

For the identification of conflicts between waterways and preliminary tower locations, a conflict location has been identified if the tower intersects with a waterway and/or is within a buffer width of a waterway. A buffer width has been applied to the analysis to identify towers that are located within the cross-section of a waterway or within the waterways corresponding flood plain.

Rating System 1 is outlined in Table 3-1.

A buffer width for each rating category was developed through interrogation of several identified waterways for each stream order and the SRTM Lidar and aerial photographs. The buffer widths were developed through interrogations of waterways and their corresponding stream orders along the proposed route alignments. This interrogation involved reviewing a sample of waterways for each stream order; where the cross-sectional profiles were measured and compared to the terrain profiles of the surrounding floodplain and aerial satellite photographs. From this interrogation, a buffer width for each stream order was developed to represent the potential areas around the tower that would be influenced and at risk from a nearby waterway. For example, a tower within 300 m of a waterway with stream order of 7 would be within the floodplain of the waterway and be potentially at risk. It would consequently have a conflict categorisation of CAT 3.

Table 3-1 Conflict Categorisation Rating System for Preliminary Tower Location

Description	Conflict Category	Stream Order	Buffer Width Rule
Tower location conflicts with (or is within 50 m of) minor tributaries. No flood modelling required. Consider a review location.	CAT 1	1	50 m
	CAT 1	2	50 m
Tower location conflicts with (or is within 100 m of) mid-order waterways. Review tower location and consider flood modelling.	CAT 2	3	100 m
	CAT 2	4	200 m
Tower location conflicts with (or is within 200 – 300 m of) major waterways and rivers. Review tower location, and route and location should be changed. Flood modelling should be considered.	CAT 3	5	200 m
	CAT 3	6	200 m
	CAT 3	7	300 m
	CAT 3	8	300 m
	CAT 3	9	300 m
	CAT 3	10	300 m
	CAT 3	11	300 m

Rating System 2: Conflicts between waterways and proposed route corridor or desktop access tracks

For the identification of conflicts between waterways and proposed route corridor or desktop access tracks, a conflict location has been identified if the corridor or access track intersects with a waterway.

Rating System 2 is outlined in Table 3-2.

Table 3-2 Conflict Categorisation Rating System for Proposed Route Corridor or Desktop Access Tracks

Description	Conflict Category	Stream Order
No conflict or minimal conflict with low order tributary. No change or flood modelling required.	CAT 1	1 – 2
Conflict on minor riverway. Route/tower/access track location to be revised if possible, otherwise flood modelling required at Stage 2.	CAT 2	3 – 4
Conflict on high stream order tributary or major waterway. Flood modelling required at Stage 2.	CAT 3	Greater than 5

4 Results

4.1 Desktop Assessment

It consisted of data collation and a high-level gap analysis, utilising the rating system described in Table 4-1. This rating system was used to flag issues that may affect the uses and acceptability of the data/information.

The data collated and gap assessment findings are outlined in Table 4-2.

Table 4-1 High Level Data Gap Analysis Rating System

Category	Description	Review Rating	Fit for Use
No issue	The data/information reviewed is acceptable to progress to spatial analysis and/or use for Stage 2.	0	Yes
Minor Issue	The data/information has a potential issue, but unlikely to significantly affect spatial analysis or Stage 2.	1	Yes
Moderate Issue	The data/information has a potential issue that could affect the spatial analysis and/or Stage 2. It may be resolved by explanation or acceptance of limitations of data.	2	More information required
Major Issue	The data/information reviewed has potential issues that are unable to be resolved and should be rectified before used in spatial analysis or Stage 2.	3	No

Table 4-2 Data collated and gap analysis results

Description	Format	Source	Findings/Comments	Rating
Proposed Route – Alignment 1 and Alignment 2	KMZs	TransGrid	KMZ assumed to show the full route for Alignment 1 and Alignment 2. It was required to be processed into GIS format for the spatial analysis and to create the 2km corridor.	0
Proposed Route – Alignment 3	KMZs	TransGrid	KMZ assumed to show the full route for Darlington South Route Option. It was required to be processed into GIS format for the spatial analysis and to create the 2km corridor.	0
Preliminary Tower Locations	KMZs	Beca	KMZ showed tower locations only for the full route for Alignment 1 and Alignment 2. Tower locations range from 350 to 600 m. Towers for Alignment 3 were not included for the spatial analysis.	1
Desktop Assess Tracks	DWG	Beca	DWG shows desktop assess track of Alignment 2 of the proposed route and include existing, new access track and major and minor roads. Access tracks for Alignment 1 and Alignment 3 were not included for the spatial analysis.	1
SRTM 1 Sec Hydro Enforced Lidar	Esri Database (.adf)	Creative Commons © GeoScience Australia	This 2011 Lidar covers the whole of Australia and captures flow paths based on SRTM elevations and mapped stream lines and supports delineation of catchments and related hydrological attributes. Although the SRTM lidar is at 1 arc-sec resolution (approximately 30m grid) and is the only opensource Lidar dataset covering whole Murry Darling Catchment and utilised for large regional modelling. It was used for the spatial analysis and will be utilised for Stage 2.	0
TransGrid Project Lidar	.laz	TransGrid	High quality project lidar covering the corridor. This lidar does not cover the full catchment area (over 1 million km^2) required for the spatial analysis or the full catchment to be modelled in Stage 2. However, a vertical assessment will be performed between the SRTM Lidar and the project lidar data, as a difference check during Stage 2.	1
Aerial Imagery	JPEG	Esri World Imagery	Aerial Imagery at resolution to provide sufficient detail. Latest aerial imagery for the whole of the Murray Darling Basin. No high resolution imagery has been obtained due to the scale of the spatial analysis. Imagery is fit for spatial analysis.	0
Land Use and Soil Classes	Shp Esri Databases (.gbd)	Creative Commons © NSW Department of Planning, Industry and Environment	Data is dated 2017 and is the latest data for the whole of NSW. Although land use may have changed within the last 2 years, quantifying the changes would be effort and resource intensive, with marginal effect on Stage 2. The data is deemed suitable to be used in Stage 2.	1

Description	Format	Source	Findings/Comments	Rating
Vegetation Classes	Shp Esri Databases (.gbd)	Creative Commons © NSW Department of Planning, Industry and Environment	Data is dated 2016 and is the latest database available for the whole of NSW. Although vegetation extents may have changed within the last 3 years, quantifying changes would be effort and resource intensive, with marginal effect on Stage 2. The data is deemed suitable to be used in Stage 2.	1
Murray Darling Basin Catchment Files	Esri Databases (.gbd)	Creative Commons © Murray Darling Basin Authority	The Murray Darling Basin Database is an open source database of the whole basin to provide spatial information on relationships and characteristics of hydrological features (Streams, Aquifers, Storages, Wetlands and man-made structures). Useful database for comparison with spatial analysis results.	0
Surface Water Information (Hydrology Database)	Esri Databases (.gbd)	Creative Commons © GeoScience Australia	The National Surface Hydrology Database is an open source database of the whole of Australia to provide spatial information on relationships and characteristics of hydrological features (Catchments, Streams, Aquifers, Storages, Wetlands and man-made structures) Useful database for comparison with spatial analysis results.	0
NSW Irrigation System Information	NA	NA	No data has been sourced for Stage 1 and will not be sourced until agreement on flood modelling methodology and commencement of Stage 2. This data has the potential to impact the outcome from Stage 2. However, is excluded from the scope of the flood modelling, as Stage 2 is to model an open system (see disclaimer).	2
Stream Gauge Data	NA	NA	No data has been sourced for Stage 1 and will not be sourced until agreement on flood modelling methodology and commencement of Stage 2. Stream gauge information has the potential to impact the outcomes from Stage 2 and will be sourced at commencement of Stage 2.	2
Rainfall Data	CSV TXT	Bureau of Metrology (BoM) Australian Rainfall and Runoff (ARR) 2019 Data Hub	BoM website and ARR2019 datahub provides required data for Stage 2. Specific data based upon spatial distribution will be sourced upon commencement of Stage 2.	0
Temporal Patterns, Areal Distribution and Reduction Factors etc	CSV TXT	Bureau of Metrology (BoM) ARR 2019 Data Hub	ARR 2019 datahub provides required data for Stage 2. Specific data based upon spatial distribution will be sourced upon commencement of Stage 2.	1

4.2 Spatial Analysis

The digital files have been generated and provided of the conflict locations and categorisation identified through Stage 1 Spatial Analysis. The information contained within these files is for the sole purpose of the assessment of the proposed transmission line route for the EnergyConnect project. The information has been produced based upon the validity of the project data provided at the time of undertaking this analysis and is considered appropriate for this stage of the assessment. The information provided in these files is **NOT** be used for alternative purposes.

A summary of the GIS files produced, and their attributes is outlined in Table 5-1. Appendix A contains the summary tables that outline the total number of each conflict category locations for:

- Preliminary Tower Locations;
- Route Corridor; and
- Desktop Access Tracks.

5 Recommendations

The digital files provided can be used within GIS software to review these conflict locations to inform design development for route alignment and tower locations. For example:

- Map 1 (located in Appendix A) provides an example of the spatial analysis output files at the proposed route at Darlington Point. This map shows four locations along the proposed route which are Category 3 (RED Triangles and Dots). This flags that these locations and towers should be reviewed by designers to determine whether the route can avoid several major waterways within the area, minimise the number of towers within these regions and other possible solutions.

The outcomes of Stage 1 will be used to form the flood modelling approach for Stage 2 – Targeted 2D Tuflow HPC modelling and will be developed with consultation with TransGrid.

Table 5-1 Summary of GIS Files produced for Stage 1 Spatial Analysis

No.	File Name	Description	Attribute No.	Attribute Name	Attribute Description	Format	Projection
1	20191010_EC_Stage1_Streamline_001	Derived stream lines	0	STR_ID	Stream Id	KML shp	WGB84
			1	STR_ORD	Stream Order (Strahler)		
			2	from_node	Upstream node/junction of stream line		
			3	to_node	Downstream node/junction of stream line		
2	20191010_EC_Stage1_Tower_Categorised_001	Conflict categorised preliminary tower locations	0	NAME	Name	KML shp	WGB84
			1	SOURCE	Name of source route KMZ file		
			2	ST_ID	Tower identifier		
			3	STR_ID	Conflicts stream Id		
			4	STR_ORD	Conflicts Stream Order (Strahler)		
			5	CATEGORY	Conflict Category based on Table 3-1		
3	20191010_EC_Stage1_RouteCorridor_Categorised_001	Conflict categorised locations with route corridor	0	OBJECTID	Conflict location identifier	KML shp	WGB84
			1	STR_ID	Conflicts stream Id		
			2	STR_ORD	Conflicts Stream Order (Strahler)		
			3	CATEGORY	Conflict Category based on Table 3-2		

No.	File Name	Description	Attribute No.	Attribute Name	Attribute Description	Format	Projection
4	20191010_EC_Stage1_AccessTrack_ Categorised_001	Conflict categorised locations with desktop access tracks	0	OBJECTID	Access track identifier	KML shp	WGB84
			1	TYPE	Name of type of access track or road type		
			2	STR_ID	Conflicts stream Id		
			3	STR_ORD	Conflicts Stream Order (Strahler)		
			4	CATEGORY	Conflict Category based on Table 3-2		
5	20191010_EC_Stage1_DesktopAccess Tracks_001	Desktop access tracks	0	TYPE	Name of type of access track or road type	KML shp	WGB84
			1	SOURCE	Name of source DWG file		
6	20191010_EC_Stage1_RouteCorridor_001	Combined route corridor (2km wide)	0	NAME	Name of source alignment KMZ	KML shp	WGB84
			1	PERIMETER	Route corridor perimeter		
			2	AREA	Route corridor enclosed area		

APPENDIX A

From the spatial analysis, the following tables summarise the total number of each conflict category locations for:

- Preliminary Tower Locations;
- Route Corridor (2km wide); and
- Desktop Access Tracks (New Access Track, Existing Access Tracks, Minor Roads and Major Roads)

Preliminary Tower Locations

Table 5-2 Summary of the number of preliminary tower location conflicts

Conflict Category	No. of Towers
CAT 1	126
CAT 2	156
CAT 3	208
Towers with no conflict (NA)	787

Route Corridor

Table 5-3 Summary of the number of conflict locations along the route corridor.

Conflict Category	No. of Conflict Locations
CAT 1	1682
CAT 2	393
CAT 3	127

Access Tracks

Table 5-4 Summary of the number of conflict location on desktop access tracks (Access Tracks New)

Conflict Category	No. of Conflict Locations
CAT 1	175
CAT 2	45
CAT 3	15

Table 5-5 Summary of the number of conflict location on desktop access tracks (Access Tracks Existing)

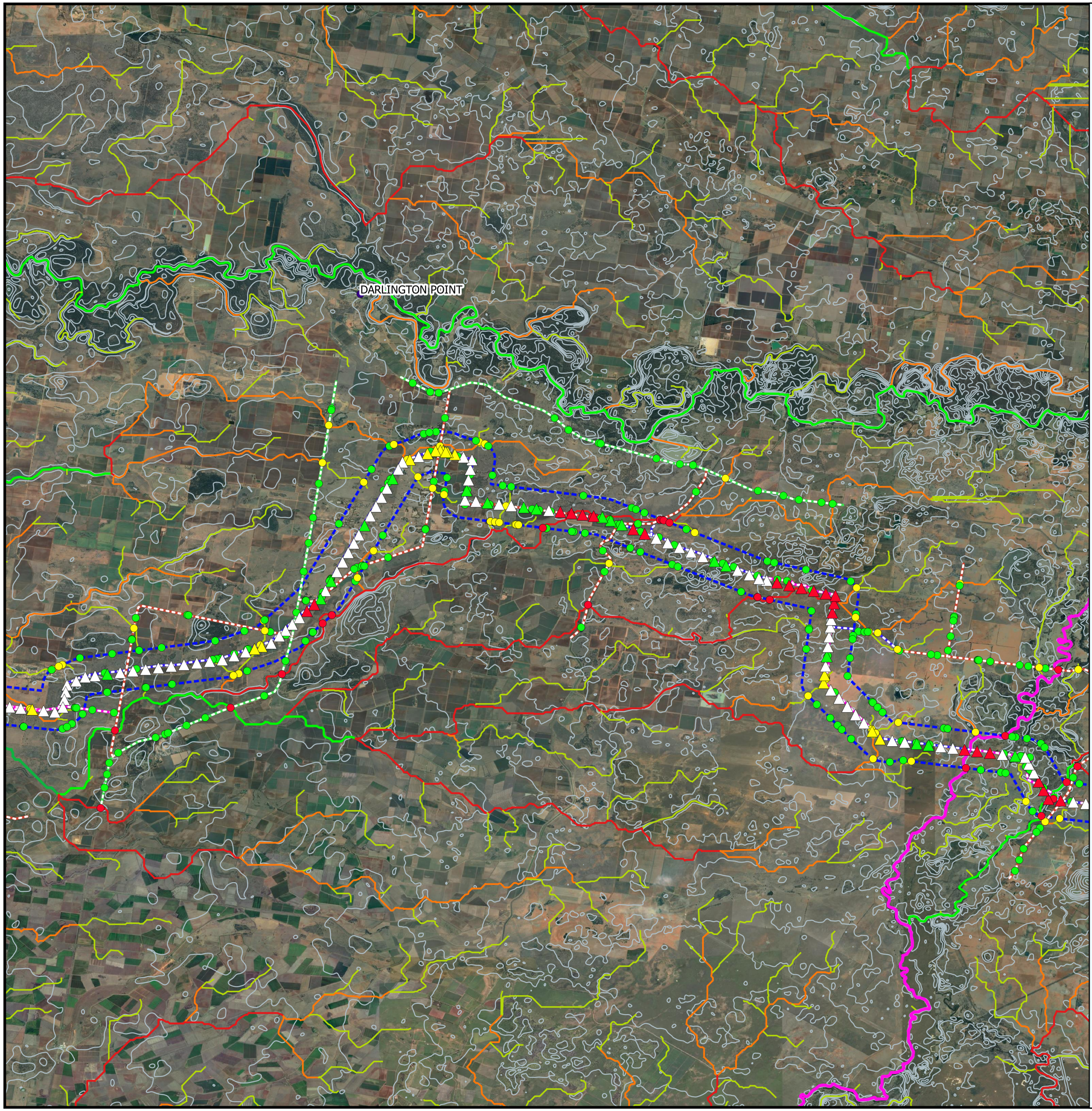
Conflict Category	No of Conflict Locations
CAT 1	50
CAT 2	15
CAT 3	6

Table 5-6 Summary of the number of conflict location on desktop access tracks (Major Roads)

Conflict Category	No of Conflict Locations
CAT 1	85
CAT 2	21
CAT 3	8

Table 5-7 Summary of the number of conflict location on desktop access tracks (Minor Road)

Conflict Category	No of Conflict Locations
CAT 1	319
CAT 2	89
CAT 3	23



Legend

20191027_EC_Stage1_Tower_Categorised_001
- No conflict (Not Categorised)
- CAT 1
- CAT 2
- CAT 3

20191027_EC_Stage1_RouteCorridor_Categorised_001
- CAT 1
- CAT 2
- CAT 3

20191027_EC_Stage1_AccessTrack_Categorised_001
- CAT 1
- CAT 2
- CAT 3
- 20191027_EC_Stage1_RouteCorridor_001
- SRTM_CONTOURS_2m_Interval (2km corridor)

20191027_EC_Stage1_DesktopAccessTracks_001
- ACCESS_TRACK (Existing)
- ACCESS_TRACK (NEW)
- MAJOR_ROAD
- MINOR_ROAD

20191027_EC_Stage1_Streamline_001 (STREAM ORDER)
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11

MAP 1 - Conflict Locations at Darlington Point
EnergyConnect
20191027

Memorandum

To:	Peter Jones, Mark Borkin (TransGrid)	**Date:**	31 March 2020
From:	Luke McLean (Beca)	**Our Ref:**	2580421
Copy:	Mark Jones, Sanu Maharjan (TransGrid)		
Subject:	Project EnergyConnect – Hydrological Risk Assessment – Final Dataset		

Beca has undertaken the hydrological risk assessment along the proposed transmission line alignment, including the substations, for Project EnergyConnect (PEC).

This assessment is based on the kmz files listed below for the alignment provided by TransGrid and other publicly available information at the time of writing this memorandum:

- BURONGA to SA-BORDER 330 kV DC Line (30.01.2020).kmz
- DINAWAN Sub – BURONGA Sub 330 kV DC Line (30.01.2020).kmz
- WAGGA WAGGA Sub – DINAWAN Sub 330kV DC Line (30.01.2020).kmz
- WAGGA WAGGA Sub – GUGAA Sub 330kV DC Line (30.01.2020).kmz
- Buronga – Red Cliffs 220kV DC Line (31.01.2020).kmz

Due to the significantly large catchment size, the associated modelling constraints and tight timeframes, the hydrological risk assessment was delivered as a two-step process: Interim dataset (issued on 5 February 2020) and Final dataset (this deliverable).

Please refer to the following files (attached) for the final dataset:

- *EC_400m_TP04_01pALLDUR_DepthMax.tif*
- *EC_400m_TP04_01pALLDUR_HazardMax.tif*
- *EC_400m_TP04_01pALLDUR_VelocityMax.tif*
- *MaxRESULTS_Buronga_RedCliffs_220kV_DC_line_Structure_Location.kmz*
- *MaxRESULTS_Buronga_to_SA-BORDER_330kV_DC_line_Structure_Location.kmz*
- *MaxRESULTS_DINAWAN_Sub-BURONGA_Sub_330kV_DC_line_Structure_Location.kmz*
- *MaxRESULTS_WAGGA_WAGGA_Sub-DINAWAN_Sub_330kV_DC_line_Structure_Location.kmz*
- *MaxRESULTS_WAGGA_WAGGA_Sub-GUGAA_Sub_330kV_DC_line_Structure_Location.kmz*

This final dataset is based upon a single 1% AEP design flood event magnitude and the maximum of all duration results. A representative temporal pattern (TP04) was adopted for these simulations.

This risk assessment was developed for the intended purpose of providing additional information to the PEC project team, including the tenderers, regarding the flood risks associated with the proposed alignment and does not constitute a full flood study.

The Hydrologically Enforced Shuttle Radar Topography Mission (SRTM) data adopted for the study forms the only project-wide dataset available. The SRTM data is a global terrain dataset captured via the Space Shuttle Endeavour as part of an international effort to develop global digital elevation models. This dataset as has a known vertical accuracy of up 16 metres absolute error at 90% confidence. Random sampling of the SRTM data through spot tests conducted by Beca demonstrated that within the project corridor this vertical accuracy is closer to ±7-8 metres vertically, relative to LiDAR information. Resulting from this spot analysis, if water surface elevation is required to be known (i.e. flood level) the flood depth results are required to be positioned against actual surface level information (i.e Lidar or Survey). Noting the surface elevation difference between the adopted SRTM data, combined with the variation in actual terrain levels and other geographical features that may not be captured on the 400-metre modelling grid, a vertical buffer of ±3 metres is recommended to be applied to the flood depths produced from the flood risk assessment.

The final dataset is provided and intended to be used in GIS format.

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